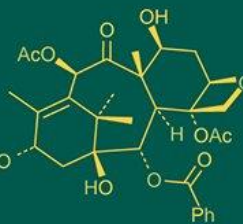
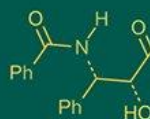


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Elucidating the influence of pre-harvest hexanal treatment on physico-chemical composition of litchi cv. Purbi

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Abstract

The present study was conducted at Horticulture Garden, Department of Horticulture (Fruit Science), Bihar Agricultural University, Sabour, Bhagalpur, Bihar, during the year 2024 with objective to find out the suitable dose of hexanal with relation to physico-chemical characteristics of litchi. Four different treatment concentrations of hexanal i.e., T₁-0.25%, T₂-0.50%, T₃-0.75% and T₄-control were used as pre-harvest spray on litchi trees at colour break stage. Among all the treatments, T₁ (0.25% hexanal) treatment at pre-harvest stage showed the best result for physical and biochemical parameters like fruit weight (21.59 g), fruit length (39.10 mm), fruit width (33.60 g), pulp weight (14.39 g) and peel weight (2.32 g) seed weight (1.72 g), pulp:seed (9.99). The maximum recorded value for TSS (20.04 °Brix), total sugar content (13.54%), ascorbic acid content (32.87 mg/100 g FW), total anthocyanin content (34.18mg/100 g FW), antioxidant capacity (16.53 µmol Trolox equiv.per 100 g), total phenol content (821.89 mg/100 g FW) whereas, maximum (0.62%) titratable acidity was recorded in case of T₄ (control) and minimum (0.45%) titratable acidity in T₁ (0.25% hexanal).

Keywords: Litchi, hexanal, colour break stage, fruit physico-chemical quality

Introduction

Litchi (*Litchi chinensis* Sonn.), often referred as the “queen of subtropical fruits,” is valued globally for its attractive red pericarp, juicy aril, pleasant aroma and high nutritional content (Nath *et al.*, 2018) [17]. Despite its premium market demand, the fruit suffers from extremely limited shelf life due to rapid senescence, pericarp browning, desiccation and microbial decay (Jiang and Fu, 1999) [16]. Only a handful of nations grow litchi fruit because of its extremely specific weather requirements. It typically thrives in a climate that is damp, has plenty of rainfall, and is frost-free. India ranks second in terms of litchi production and area, right after China. On an average, 728,000 MT of litchi are produced in India. Currently, 99,000 hectares are used to grow this fruit (NHB, 2021-22) [13]. Litchi is a significant part of the producers' economy, with these five Indian states—Bihar, West Bengal, Assam, Tripura, and Jharkhand—producing 78% of the country's total output. Bihar produces 43% of all litchi and occupies over 35% of India's litchi production territory. Being non-climacteric in nature, litchi does not continue ripening after harvest but physiological and biochemical degradation begins almost immediately leading to substantial postharvest losses. Among the commercially important cultivars, cv. Purbi is widely grown in the Bhagalpur region for table purposes due to its attractive fruit size, sweetness and consumer preference. The cv. Purbi produces medium-sized, oblong-conical fruits that ripen in late May or early June. It yields 90-100 kg per tree on average (NRC-Litchi). The aforementioned regions experience seasonal overproduction, which results in a surplus on the market and lower litchi prices. Litchi's senescence phase begins shortly after ripening because it is a non-climacteric fruit; hence, its flavor, nutritional value, and peel color all deteriorate more rapidly at this time (Jiang *et al.*, 2004) [15]. Therefore, strategies aimed at preserving membrane integrity and suppressing oxidative enzymes are considered effective for extending shelf life. Hexanal a naturally occurring C6 aldehyde produced via the lipoxygenase pathway and is classified as “Generally Recognized as Safe” (GRAS) and is known to inhibit PLD activity, thereby stabilizing cell membrane and slowing senescence (Paliyath *et al.*, 1999; Paliyath & Murr,

2007)^[12, 11]. Hexanal has been successfully used to extend shelf life and maintain quality in several climacteric and non-climacteric fruits (Sharma *et al.*, 2010; Cheema *et al.*, 2014)^[10, 9]. The present study was therefore undertaken to evaluate the effect of preharvest application of different doses of hexanal on physiochemical characteristics of litchi cv. Purbi.

Materials and methods:

The experiment was conducted at the Horticulture Garden, Department of Horticulture (Fruit Science), Bihar Agricultural University, Sabour, Bhagalpur, Bihar, during the years 2023-2024, titled 'Elucidating the influence of pre-harvest hexanal treatment on fruit quality and biochemical composition of litchi cv. Purbi.'

Experimental Plot, Spraying and Harvesting

Pre-harvest foliar application was carried out on litchi cv. Purbi at the colour break stage using four treatments: T₁ (0.25%), T₂ (0.50%), T₃ (0.75%) and T₄ (control). The experiment was conducted on twenty Purbi litchi trees grown in the Horticulture Garden of Bihar Agricultural College, Sabour. Fruits were harvested at full maturity when approximately 90-100% of the pericarp had developed red coloration. Fully mature fruits receiving pre-harvest hexanal treatment were collected during the early morning hours for post-harvest studies from uniformly aged trees maintained under standard orchard management practices. For experiment Purbi variety of litchi was taken for pre-harvest spray of hexanal with three concentrations and one control. Hexanal was sprayed only once at colour break stage and it was laid out in randomized block design along with five replication.

Preparation of solution for pre-harvest spray

Hexanal (C₆H₁₂O; molecular weight 100.16 g/mol) is a straight-chain aliphatic aldehyde used in the present study for pre-harvest application. Three treatments of different hexanal concentration viz. T₁ (0.25%), T₂ (0.50%) and T₃ (0.75%) were formulated for experimental treatments, along with T₄ (control). For the 0.25% treatment, 38.2 mL of

hexanal was initially dissolved in 30 mL of alcohol under continuous stirring and subsequently diluted with distilled water to obtain 15 L of solution. The 0.50% and 0.75% solutions were prepared using 76.5 mL and 114.75 mL of hexanal dissolved in 75 mL and 100 mL of alcohol respectively, followed by dilution to the final volume. Each treatment was replicated five times and foliar application was carried out at a rate of 3 L per plant, requiring 15 L of solution per treatment.

Observations recorded

Physical parameters of litchi fruits

Uniform sized fruits were selected based on fruit weight, pulp weight, peel weight, seed weight, fruit length and fruit width. The weight was measured using a digital weighing balance (Make: Wensar; Model: PGB6100, Tamil Nadu, India). In respect of weight, average of three randomly selected fruits was weighed and averaged in grams. A digital vernier calliper (Make: Mitutoyo; Model: 500-19-20, Kawasaki, Japan) was used to measure the fruit length and width which was expressed in mm.

Biochemical parameters of litchi fruits

Total soluble solids (TSS) were measured at 25 °C using a digital refractometer (PAL 3, Atago Ltd., Tokyo, Japan) and was expressed as degree Brix (B).

Total sugar content in mango fruits was quantified following the methods of Lane and Eynone (1923)^[8].

Ascorbic acid content was determined by titrating freshly extracted juice against 2,6-Dichlorophenol indophenol dye method Jones and Hughes (1983) and calculated using following formula and reported as mg per 100 g of FW.

$$\text{Ascorbic acid} = \frac{\text{Titre value} \times \text{dye factor} \times \text{vol. made up}}{\text{aliquot of extract} \times \text{vol. of sample taken}} \times 100$$

Titrateable acidity, pulp was ascertained using the titration method of AOAC, 2000^[1] and for this titration against 0.1 N sodium hydroxide solution was done. Phenolphthalein dye was used as an indicator. The finding was expressed as a percentage of citric acid. Formula used is:

$$\text{Titrateable acidity} = \frac{\text{Titre value} \times \text{N of alkali} \times \text{equi. wt. of acid}}{\text{vol. of sample taken for estimation} \times \text{wt. or vol. of sample (g)} \times 1000} \times 100$$

Total anthocyanin content was determined with a double-beam UV-Vis spectrophotometer and was expressed in mg/100 g which represented the overall anthocyanin concentration.

Total antioxidant capacity of the litchi pericarp was

determine by CUPRAC assay method according to the Apak *et al.* 2008^[2].

Total phenol content of litchi pericarp methodology described by Singleton *et al.* 1999 was used and expressed in mg equivalent of gallic acid. Formula used is:

$$\text{Total phenol content} = \frac{A \times \text{volume made up (mL)} \times \text{dilution}}{0.02 \times \text{aliquot taken (mL)} \times \text{wt. of sample (g)} \times 1000} \times 100$$

Statistical Analysis

Data recorded for the different parameters were compiled and subjected to statistical analysis using the OPSTAT software package developed by HAU, Hisar, Haryana. Experimental observations collected during the course of the study were analysed to assess treatment effects. The analysis of variance (ANOVA) procedure, as proposed by R.A. Fisher (1948), was employed for the Randomized Block Design (RBD).

Results and Discussion

Physical parameters

The influence of different hexanal concentrations on physical parameters is summarized in figure below. The greatest mean fruit weight (21.59 g) was obtained with the 0.25% hexanal treatment (T₁), which did not differ significantly from 0.50% treatment (T₂) and was followed by the control (T₄). Conversely, the 0.75% hexanal treatment (T₃) resulted in the lowest fruit weight (18.60 g).

Analysis of variance revealed significant treatment effect ($p < 0.05$). In terms of pulp weight, maximum pulp weight was recorded in T_1 -0.25% i.e. 14.39 g followed by T_2 and T_4 -control while, minimum was observed in T_3 -0.75%. The data presented in the table indicates that the highest peel weight (2.32 g) was obtained with the 0.25% treatment (T_1). In contrast, the lowest peel weight (1.94 g) was recorded under the 0.75% treatment (T_3), which was statistically comparable to the control (T_4). Seed weight followed a pattern comparable to other fruit components. The highest mean seed weight (1.72 g) was recorded under the 0.25% treatment (T_1), whereas the lowest value occurred at 0.75% (T_3), which was statistically at par with the 0.50% treatment (T_2) and the control (T_4). Fruit length showed a response pattern comparable to other physical attributes. The greatest mean fruit length (39.10 mm) was observed under the 0.25% treatment (T_1), which was statistically comparable to the 0.75% (T_3) and 0.50% (T_2) treatments. In contrast, the lowest fruit length (376.22) was recorded in the control (T_4), which didn't differ significantly from T_3 . A trend comparable to other fruit size parameter was observed for fruit width. Fruit treated with 0.25% concentration (T_1) showed the maximum mean fruit width (33.60 mm)

followed by the 0.50% (T_2) and 0.75% (T_3) treatments, with no significant differences among them. The minimum fruit width (31.55 mm) was noted in the control (T_4). The physical parameters were not much influenced by pre-harvest application of hexanal treatments. This might be due to the fact that the pre-harvest application of hexanal was given after active fruit growth stage i.e. at colour break stage (15 days before harvesting).

The physical characteristics of the fruits, including fruit weight, pulp weight, peel weight, fruit length and fruit width, showed only minor variation in response to the pre-harvest application of hexanal. Although slight numerical differences were observed among treatments, these variations were not substantial, indicating that hexanal had a limited influence on the physical attributes of the fruits. The response can be attributed to the stage of application, as the pre-harvest spray was applied after the completion of the major fruit growth and development phase, during which fruit size and structural traits are largely determined. As a result, hexanal application at this stage was unable to induce marked changes in physical parameters. Similar trends have been reported by Jaspa (2020) [6] in tomato and Uttekar (2021) [5] in acid lime.

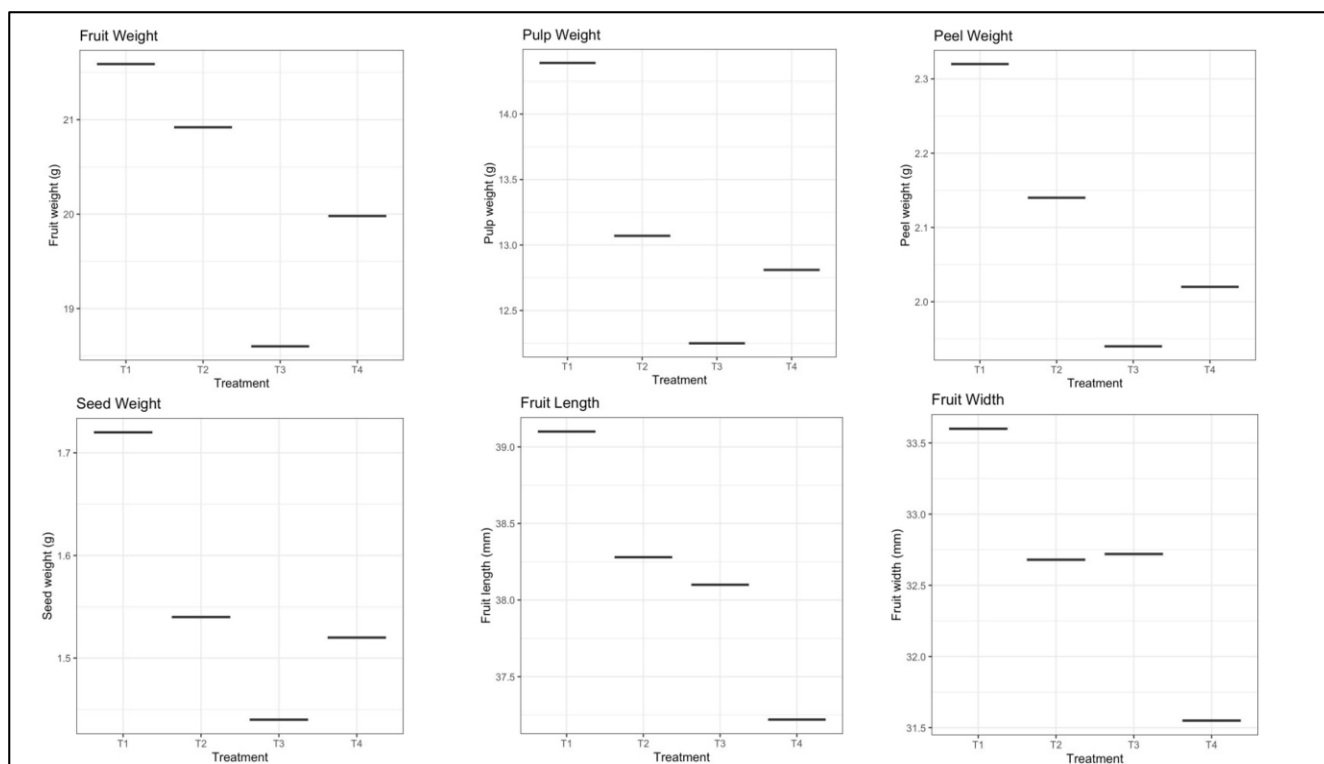


Figure 1: Effect of hexanal on physical parameters of litchi cv. Purbi

Biochemical parameters

The influence of pre-harvest hexanal application at varying concentrations on biochemical attributes of litchi cv. Purbi is presented in figure below. Statistical analysis revealed significant treatment effects for all biochemical parameters evaluated ($p < 0.05$). Total soluble solids (TSS) were highest in fruits treated with 0.25% hexanal (T_1 ; 20.04 °Brix), which was statistically comparable to the 0.50% treatment (T_2), while the lowest TSS value (17.74 °Brix) was recorded in the control (T_4), remaining at par with the 0.75% (T_3). Similar trend was observed for the total sugar content, with the maximum value (13.54%) recorded in T_1 , followed by T_2 and T_3 , whereas the control exhibited the lowest sugar

content (10.80%). Titratable acidity was significantly higher in the control treatment (T_4 ; 0.62%), followed by T_3 and T_2 , while the minimum acidity (0.45%) was observed in T_1 . Ascorbic acid content was highest in fruits receiving the 0.25% hexanal concentration (32.87 mg 100⁻¹ FW), followed by T_2 and T_3 , whereas the lowest concentration (30.06 mg 100⁻¹ FW) was recorded in the control. Likewise, total anthocyanin content was maximized in T_1 (34.18 mg 100⁻¹ FW), followed by T_2 and T_3 , with the minimum value observed in T_4 . Antioxidant capacity exhibited a similar response with the highest value recorded in T_1 (16.53 μmol Trolox equivalent g⁻¹ FW), followed by T_2 and T_3 , while the lowest antioxidant capacity was noted in the control (15.32

μmol Trolox equivalent g^{-1} FW). Total phenolic content was also significantly influenced by hexanal treatments, with the highest concentration observed in T_1 ($821.89 \text{ mg } 100^{-1} \text{ FW}$),

followed by T_2 and T_3 and the lowest phenolic content recorded in the control ($777.01 \text{ mg } 100^{-1} \text{ FW}$).

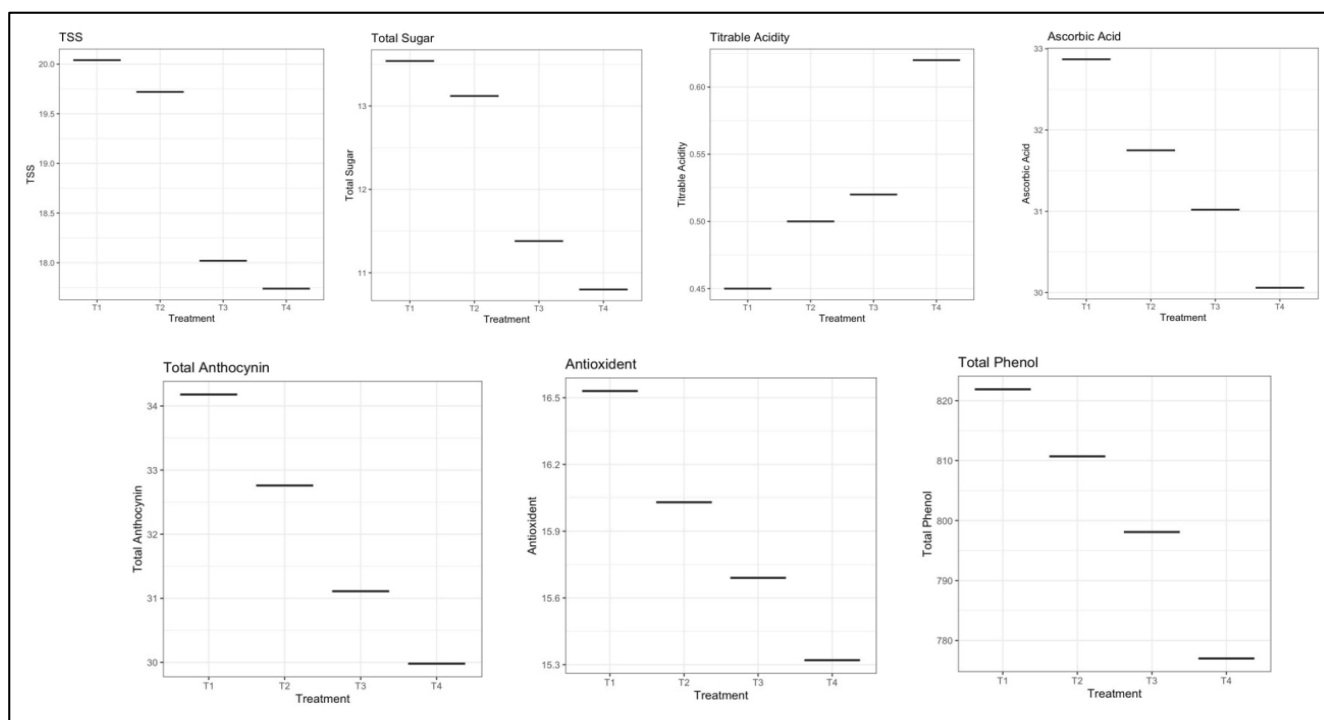


Figure 2: Effect of hexanal on biochemical parameters of litchi cv. Purbi

Pre-harvest application of hexanal markedly influenced the biochemical composition of litchi fruits during early storage, with lower concentrations showing greater efficacy in preserving quality attributes. The enhancement of TSS and total sugar content in hexanal-treated fruits may be attributed to the delayed utilization of carbohydrates during respiration, resulting from reduced metabolic activity. Lower titratable acidity in treated fruits further indicates a slowdown in organic acid degradation which commonly associated with delayed ripening and senescence. Hexanal is known to inhibit phospholipase D (PLD), a key enzyme involved in membrane lipid degradation. Suppression of PLD activity helps in maintaining membrane integrity, thereby reducing cellular leakage and oxidative stress. This mechanism likely contributed to the higher retention of ascorbic acid, anthocyanins, phenolic compounds and overall antioxidant capacity observed in hexanal treated fruits. Improved membrane stability also limits oxidative degradation of bioactive compounds, thereby enhancing antioxidant potential and nutritional quality. The superior performance of the 0.25% hexanal treatment suggests that lower concentration is more effective in modulating metabolic pathways without inducing phytotoxic effects. In contrast, higher concentrations may offer diminished benefits due to possible metabolic imbalance. Overall, pre-harvest hexanal application appears to be an effective strategy for enhancing biochemical quality and extending the post-harvest life of litchi fruits by regulating ripening-associated biochemical processes. Similar trends have been reported by Samwel *et al.* (2020) [3] in orange and Sharma *et al.* (2023) [4] in Indian jujube.

Conclusion

Pre-harvest application of hexanal significantly improved biochemical quality of litchi (*Litchi chinensis* Sonn.) cv.

Purbi during early storage with minimal effects in physical attributes. The 0.25% hexanal treatment was most effective, enhancing sugars, ascorbic acid, anthocyanins, phenolics and antioxidant capacity while reducing titratable acidity. These responses are consistent with hexanal-mediated inhibition of phospholipase D, leading to improved membrane stability and delayed senescence.

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