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# A Comprehensive Study of Hexanal Formulation on Extending Shelf Life of Custard Apple (*Annona squamosa* L.)

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***Authors' contributions***

*This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.*

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## ABSTRACT

Shelf life of custard apple is limited due to climacteric nature. In the present study, two application methods along with different concentration of hexanal formulations were used, first hexanal vapour at different concentrations (0.005, 0.01, 0.02, 0.05% v/v) and second hexanal dip (0.5, 1, 1.5, 2% v/v) along with control were evaluated on custard apple dipping fruits for 2 min and 4 min and store at ambient temperature (27±2ºC). Hexanal filter paper dip in 0.05% concentration effectively maintained the firmness, total sugar, reducing sugar, preserved $L^*$, $a^*$, $b^*$ value, extend shelf life and maximum BC ratio during storage from day 1 to days 14 as compare to control. Therefore, we concluded that hexanl vapour(0.05%) was effective to use post harvest technology for custard apple.

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*Keywords: Custard apple; shelf life; firmness; BC ratio; hunter colour.*

## 1. INTRODUCTION

In India, custard apple is locally known as "Sitaphal" which is growing naturally wild in forest of various part of country and worldwide. It belongs to the family Annonaceae having chromosome number 2n=14. Tropical America is known for central of origin of custard apple. Genus *Annona* have aggregate type of fruit. In India, custard apple is grown in area 46,000 Ha, production 401,000 MT [1]. In Rajasthan major tract of custard apple are Rajsamand, Chittorgarh, Udaipur, SawaiMadhopur, Bhilwara, Ajmer and Karauli districts.

Custard apple pulp have been widely appreciated due to bioactive substances such as TSS titratable acidity, total sugar content, total polyphenol index, antioxidant activity (2.88±0.2 µmolTrolox equivalent per gramfresh of custard apple pulp), protein, lipids, carbohydrate, fiber content, ascorbic acid, and vitamin $B_1$, $B_2$ and C *etc* [2].

Despite of nutritive value, custard apple trade is limited due to delicate nature and short postharvest life. Under ambient conditions custard apple become over ripen within week. In order to increase shelf life and to benefits small scale farmers by gaining an extra time to source for better market so that minimum exploitation by middleman be their during the value chain. Hexanal an aldehyde is non-toxic, ecofriendly and is having antimicrobial properties. Thus, there is a hope that hexanal can also effective on custard apple and application of which is not been tested yet. However, US Food and Drug Administration had licensed hexanal as safe additive compound. Therefore, application of hexanal formulation along with proper packaging will help to minimize the losses when it reaches to retail market. Hence the proposed work formulated to evaluate the effect of hexanal formulation on post-harvest losses such as microbial decay, physiological disorders and quality attributes in custard apple.

## 2. MATERIALS AND METHODS

### 2.1 Materials

Fresh and mature custard apple having (mean diameter 7.6 cm and weight 162 gm) of uniform size, without any defects and diseases, were harvested in month of October to December 2020. The custard apple fruit were clean carefully with water to remove dirt from their skin further. Selected custard apple were treated different concentration of hexanal vapour (0.005, 0.01, 0.02, 0.05% v/v) and dipped for 2 and 4 minutes at (0.5, 1, 1.5, 2% v/v) and water (control) and kept in CFB boxes packed in polythene bag for 24 hours after that CFB boxes were kept at room temperature (27°C±2) with the relative humidity 50±2 %.

### 2.2 Fruit Firmness, Total Sugar and Reducing Sugar

It was measured using a texture analyser (Model FT-327). It was expressed in Newton. The total sugars were determined colorimetrically by an Optima UV-VIS spectrophotometer (Model SP-3000) using anthrone reagent. A standard graph was prepared using known concentrations of glucose solutions. The sample values were plotted on the standard graph for total sugars and total sugars were expressed as percentages. Reducing sugar content was measured as suggested by Miller [3] using dinitrosalicylic acid. Sugars were extracted with hot 80 per cent ethanol in 100 mg sample. Supernatant was collected and evaporated by keeping on a water bath at 80 $^0$C and 10 ml water was added. After dissolving of sugar, 3 ml extract was pipetted out and 3 ml DNS reagent was added. 1 ml of 40 per cent Rochelle salt solution was added in hot DNS-extract mixture. After cooling, optical was measured on spectrophotometer (Double beam SL 210 UV Visible Spectrophotometer, Ellico, Hyderabad, India) at 510 nm. The value was plotted against a standard curve prepared from glucose. The figures were expressed on percentage basis.

### 2.3 Hunter Colour Values, Shelf Life,BC Ratio

Custard apple fruits were evaluated for Hunter colour (L*, a*, b*). HunterLab, Manual Version 2.5 from two points at equator region of each fruits. Instrumental color data was expressed in CIE system in term of L* (lightness), a* (redness and greenness), and b* (yellowness and blueness).The time from the day of harvest, taken by fruit to reach the optimal, edible ripe stage was counted and reported in days. The relative economics of different treatment was calculated on the basis of treatment costs and marketable value of the fruits after 14 days of storage.

Gross return (Rs./qt) = Return from fruits (Rs./qt)

$$\text{BC Ratio} = \frac{\text{Present worth of Gross return}}{\text{Present worth of Total costs}}$$

## 3. RESULTS AND DISCUSSION

### 3.1 Firmness

In present study, hexanal dip (0.5, 1, 1.5, 2% v/v) for 4 minutes recorded maximum (59 N 61 N, 62N, 63N) respectively, firmness but were having poor eating quality. Although, in all treatment declining trend of firmness, yet hexanalvapour (0.05%) showed optimum firmness (15N) and maintain keeping quality of fruits (14$^{th}$ day). However similar firmness was recorded in untreated fruit on 6$^{th}$ day of storage (Table 1). Previous studies showed that hexanal formulation slows down the activity polygalacturoase and β-galactosidase genes, resulting in increased firmness while control fruits suffered from quick loss of firmness. Extending the fruit retention time significantly reduce the post harvest losses, resulting in significant economic benefit (Cheema et al*.* [4] in Tomato, Geeta et al*.* [5] in Banganpalli mangoes, Kumar et al. [6] in nectarines).

### 3.2 Total and Reducing Sugar

Among quality attributes total sugar (Table 2) as maximum hexanal vapour (0.05%) 27.83% and minimum untreated fruits (0.54%). The results are in close view that initially, in untreated higher disintegration of complex sugars polymers to simple sugar. It could be ascribed to the hydrolytic enzymes metabolized complex sugar into simple one during storage. However, hexanal treated fruit showed less reduction in total sugar because it decreases the hydrolytic enzymatic activities of [7,8]. Further, reducing sugar was increase with advancement of ripening of custard apple (Table 3). Hexanal vapour (0.05%) recoded maximum (19.84%) as compared to control (0.01%). It was due to starch breakdown or hydrolysis of sugar during ripening [9].

### 3.3 Colour Value L*, a*, b*.

Hunter colour value L*, a*, b*. It is apparent from (Table 4) that colour coordinates L* (Lightness/Luminosity) was declined during storage and colour coordinates for a* (Greenness) and b* (Yellowness) increased significantly with ripening of custard apple fruits. Hexanal vapour (0.05%) recorded maximum colour value L* (Luminosity/lightness) 35.63 while in untreated fruits $S_0$ luminosity was (10.63) on 14$^{th}$ days storage condition. However, minimum luminosity was recorded in fruits dip in hexanal formulations for 4 minutes as their skin turn black.

The data concerning colour a* value show that minimum value for greenness (-) and maximum value for redness (+). Colour coordinates for a* (Table 5) maintain in $S_4$ (hexanal vapour 0.05%) and $S_5$ (hexanal dip 0.5% concentration for 2 minutes) treatment *i.e.* -3.36 and -1.86 respectively whereas a* maximum value (3.22, 3.03, 2.86) were recorded in treatment $S_{12}$, $S_{11}$ and $S_0$ as their skin became black due dip treatment for 4 minutes.

The data concerning colour b* value show that minimum value (-) for blueness and maximum value (+) for yellowness. It is clear from (Table 6) that $S_4$ (hexanal vapour 0.05%) showed maximum b* (45.17) and minimum value recorded in treatment with hexanal dip for 4 minutes ($S_9$, $S_{10}$, $S_{11}$ and $S_{12}$) from initial day to 14$^{th}$day of storage period. From previous study changes in colour intensity is an important indicator of maturity and quality of fresh custard apple. Further, development of light green colour is considered as an index of maturity. Cheema et al., [4] in Tomato, Geetha et al. [5] in banana reported that hexanal restrict the ripening process their by maintaining yellow colour.

### 3.4 Shelf life

Custard apples were visually examined for the presence of infection and spoilage to access the effect of hexanal formulation over control. Our results (Fig. 1) revealed that the application of hexanal formulation as vapour and dip treatment in custard apple significantly enhanced shelf life. The maximum shelf life ~14 days was recorded in treatment $S_4$ (hexanal vapour 0.05%) while (untreated fruits) $S_0$ remain fresh for only 6$^{th}$ days of storage. We found that vapour treatment maintain total sugar, reducing sugar, hunter colour, contribute to shelf life and B:C. However, in dip method (0.5, 1, 1.5, 2% v/v) for 2 and 4 minutes, colour of the fruit peel convert to brown black immediately after treatment and surface of the fruits become hard. However, in 2 minutes treatment the colour change was less compared to 4 min treatment. Although in dip treatment, firmness but other character bioactive compounds was not recorded upto to the mark to maintain quality and shelf life of custard apple. Based on the result, we concluded that beside dip treatment, vapour treatment was more effective to extend shelf life of custard apple. Previous finding revealed that hexanal have strong hindrance to PLD action and due to this it extended shelf life of fruits [10].

### 3.5 B:C

BC Ratio (Fig. 2) was recorded highest (2.88) in hexanal vapour (0.05%) followed by $S_5$ (2.61) as compared to control. Similar findings have been reported in several fruit crops like nectarines, sweet cherry *etc.* that hexanal vapour extend shelf life [6,11].

**Table 1. Effect of hexanal formulation on firmness (Newton) of custard apple**

| Ambient storage (days)→ / Treatments ↓ | Firmness (Newton) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **0** | **2** | **4** | **6** | **8** | **10** | **12** | **14** |
| $S_0$ Control | 45 | 33 | 24 | 15 | 10 | 5 | 2 | 0.5 |
| $S_1$ Hexanal vapour (Filter paper dip in 0.005% conc.) | 45 | 37 | 28 | 24 | 21 | 16 | 10 | 5 |
| $S_2$ Hexanal vapour (Filter paper dip in 0.01% conc.) | 45 | 38 | 31 | 28 | 24 | 20 | 14 | 9 |
| $S_3$ Hexanal vapour (Filter paper dip in 0.02% conc.) | 45 | 40 | 33 | 31 | 26 | 22 | 18 | 14 |
| $S_4$ Hexanal vapour (Filter paper dip in 0.05% conc.) | 45 | 42 | 34 | 32 | 28 | 24 | 21 | 15 |
| $S_5$ Hexanal dip (0.5% conc.) for 2 minutes | 45 | 40 | 32 | 29 | 25 | 23 | 19 | 13 |
| $S_6$ Hexanal dip (1% conc.) for 2 minutes | 45 | 39 | 30 | 26 | 22 | 19 | 15 | 11 |
| $S_7$ Hexanal dip (1.5% conc.) for 2 minutes | 45 | 38 | 28 | 24 | 20 | 17 | 13 | 10 |
| $S_8$ Hexanal dip (2% conc.) for 2 minutes | 45 | 38 | 27 | 23 | 19 | 16 | 12 | 9 |
| $S_9$ Hexanal dip (0.5% conc.) for 4 minutes | 45 | 48 | 49 | 51 | 53 | 54 | 57 | 59 |
| $S_{10}$ Hexanal dip (1% conc.) for 4 minutes | 45 | 50 | 51 | 52 | 54 | 56 | 58 | 60 |
| $S_{11}$ Hexanal dip (1.5% conc.) for 4 minutes | 45 | 52 | 53 | 54 | 56 | 57 | 60 | 62 |
| $S_{12}$ Hexanal dip (2% conc.) for 4 minutes | 45 | 52 | 54 | 55 | 57 | 58 | 61 | 63 |
| **SEm±** | **0.18** | **0.49** | **0.73** | **0.95** | **0.86** | **0.79** | **0.87** | **1.07** |
| **C.D. (P=0.01)** | **NS** | **1.91** | **2.86** | **3.72** | **3.36** | **3.10** | **3.42** | **4.21** |

**Table 2. Effect of hexanal formulation on total sugar (%) of custard apple**

| Ambient storage (days) → / Treatments ↓ | Total sugar (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **0** | **2** | **4** | **6** | **8** | **10** | **12** | **14** |
| $S_0$ Control | 11.71 | 19.73 | 24.51 | 28.47 | 15.09 | 11.13 | 9.26 | 0.54 |
| $S_1$ Hexanal vapour (Filter paper dip in 0.005% conc.) | 11.51 | 17.43 | 21.78 | 23.91 | 28.31 | 14.06 | 12.47 | 1.42 |
| $S_2$ Hexanal vapour (Filter paper dip in 0.01% conc.) | 11.66 | 16.20 | 21.16 | 23.05 | 28.15 | 20.86 | 15.02 | 5.07 |
| $S_3$ Hexanal vapour (Filter paper dip in 0.02% conc.) | 11.51 | 15.73 | 20.02 | 22.90 | 24.99 | 28.53 | 15.04 | 5.40 |
| $S_4$ Hexanal vapour (Filter paper dip in 0.05% conc.) | 11.61 | 13.52 | 18.89 | 20.39 | 22.21 | 24.32 | 29.29 | 27.83 |
| $S_5$ Hexanal dip (0.5% conc.) for 2 minutes | 11.67 | 13.95 | 18.78 | 21.17 | 23.07 | 25.41 | 28.16 | 27.13 |
| $S_6$ Hexanal dip (1% conc.) for 2 minutes | 11.73 | 14.40 | 19.79 | 21.88 | 25.45 | 28.21 | 16.26 | 13.44 |
| $S_7$ Hexanal dip (1.5% conc.) for 2 minutes | 11.53 | 15.41 | 20.66 | 22.26 | 28.19 | 26.03 | 13.92 | 11.71 |
| $S_8$ Hexanal dip (2% conc.) for 2 minutes | 11.71 | 16.07 | 21.13 | 23.22 | 27.57 | 25.15 | 13.08 | 10.11 |
| $S_9$ Hexanal dip (0.5% conc.) for 4 minutes | 11.61 | 11.93 | 6.14 | 5.38 | 3.51 | 3.60 | 3.72 | 1.98 |
| $S_{10}$ Hexanal dip (1% conc.) for 4 minutes | 11.64 | 11.81 | 6.25 | 5.68 | 3.03 | 3.27 | 3.25 | 1.94 |

| Ambient storage (days) → / Treatments ↓ | Total sugar (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **0** | **2** | **4** | **6** | **8** | **10** | **12** | **14** |
| $S_{11}$ Hexanal dip (1.5% conc.) for 4 minutes | 11.67 | 11.72 | 6.19 | 5.95 | 3.76 | 3.71 | 3.80 | 1.92 |
| $S_{12}$ Hexanal dip (2% conc.) for 4 minutes | 11.55 | 11.57 | 6.85 | 5.14 | 2.57 | 2.92 | 3.13 | 1.22 |
| **SEm±** | **0.25** | **0.58** | **0.28** | **0.30** | **0.30** | **0.31** | **0.19** | **0.20** |
| **C.D. (P=0.01)** | **NS** | **2.28** | **1.08** | **1.18** | **1.17** | **1.21** | **0.74** | **0.77** |

**Table 3. Effect of hexanal formulation on reducing sugar (%) of custard apple**

| Ambient storage (days) → / Treatments ↓ | Reducing sugar (%) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **0** | **2** | **4** | **6** | **8** | **10** | **12** | **14** |
| $S_0$ Control | 9.40 | 12.04 | 15.52 | 20.81 | 11.08 | 9.17 | 5.18 | 0.01 |
| $S_1$ Hexanal vapour (Filter paper dip in 0.005% conc.) | 9.54 | 11.77 | 14.80 | 18.87 | 21.27 | 11.99 | 9.45 | 0.48 |
| $S_2$ Hexanal vapour (Filter paper dip in 0.01% conc.) | 9.62 | 11.22 | 13.15 | 15.14 | 20.22 | 10.86 | 7.06 | 1.10 |
| $S_3$ Hexanal vapour (Filter paper dip in 0.02% conc.) | 9.66 | 10.79 | 12.03 | 15.90 | 18.93 | 21.53 | 8.09 | 1.38 |
| $S_4$ Hexanal vapour (Filter paper dip in 0.05% conc.) | 9.61 | 9.98 | 11.85 | 13.44 | 15.26 | 19.29 | 22.35 | 19.84 |
| $S_5$ Hexanal dip (0.5% conc.) for 2 minutes | 9.47 | 10.26 | 12.83 | 13.57 | 15.73 | 18.39 | 21.20 | 19.80 |
| $S_6$ Hexanal dip (1% conc.) for 2 minutes | 9.65 | 11.38 | 13.21 | 16.82 | 18.48 | 20.46 | 9.33 | 6.41 |
| $S_7$ Hexanal dip (1.5% conc.) for 2 minutes | 9.45 | 12.81 | 15.68 | 17.28 | 21.21 | 16.06 | 9.87 | 6.70 |
| $S_8$ Hexanal dip (2% conc.) for 2 minutes | 9.52 | 12.10 | 14.16 | 15.17 | 20.62 | 16.04 | 10.10 | 6.11 |
| $S_9$ Hexanal dip (0.5% conc.) for 4 minutes | 9.53 | 10.93 | 11.18 | 5.41 | 2.28 | 2.04 | 1.66 | 0.58 |
| $S_{10}$ Hexanal dip (1% conc.) for 4 minutes | 9.49 | 10.78 | 10.95 | 4.11 | 2.35 | 2.10 | 1.61 | 0.84 |
| $S_{11}$ Hexanal dip (1.5% conc.) for 4 minutes | 9.49 | 10.73 | 10.92 | 4.62 | 2.43 | 2.17 | 1.70 | 0.81 |
| $S_{12}$ Hexanal dip (2% conc.) for 4 minutes | 9.48 | 10.58 | 10.80 | 4.25 | 2.80 | 2.32 | 1.89 | 0.90 |
| **SEm±** | **0.02** | **0.11** | **0.16** | **0.19** | **0.31** | **0.31** | **0.21** | **0.17** |
| **C.D. (P=0.01)** | **0.07** | **0.44** | **0.64** | **0.75** | **1.23** | **1.20** | **0.83** | **0.66** |

**Table 4. Effect of hexanal formulation on hunter colour value of pulp L*of custard apple**

| Ambient storage (days) → / Treatments ↓ | Hunter colour value of pulp L* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **0** | **2** | **4** | **6** | **8** | **10** | **12** | **14** |
| $S_0$ Control | 68.70 | 59.41 | 52.56 | 50.13 | 42.4 | 31.49 | 18.92 | 10.63 |
| $S_1$ Hexanal vapour (Filter paper dip in 0.005% conc.) | 67.77 | 66.02 | 59.58 | 52.42 | 48.6 | 35.51 | 30.19 | 23.44 |
| $S_2$ Hexanal vapour (Filter paper dip in 0.01% conc.) | 69.57 | 67.74 | 61.35 | 56.71 | 51.2 | 39.73 | 33.99 | 26.48 |
| $S_3$ Hexanal vapour (Filter paper dip in 0.02% conc.) | 71.33 | 68.55 | 62.77 | 58.82 | 53.67 | 42.87 | 35.30 | 28.59 |
| $S_4$ Hexanal vapour (Filter paper dip in 0.05% conc.) | 73.87 | 68.43 | 63.49 | 60.43 | 56.78 | 49.73 | 46.42 | 35.63 |
| $S_5$ Hexanal dip (0.5% conc.) for 2 minutes | 72.22 | 67.80 | 61.09 | 57.80 | 54.51 | 46.30 | 43.96 | 32.51 |
| $S_6$ Hexanal dip (1% conc.) for 2 minutes | 68.31 | 64.73 | 56.88 | 61.79 | 53.62 | 44.33 | 37.13 | 29.73 |
| $S_7$ Hexanal dip (1.5% conc.) for 2 minutes | 69.65 | 52 | 45.23 | 30.13 | 24.65 | 16.73 | 12.76 | 9.45 |
| $S_8$ Hexanal dip (2% conc.) for 2 minutes | 71.81 | 45.56 | 34.85 | 26.74 | 18.54 | 10.42 | 6.43 | 7.19 |
| $S_9$ Hexanal dip (0.5% conc.) for 4 minutes | 68.65 | 30.53 | 18.32 | 14.35 | 10.75 | 6.21 | 3.75 | 2.18 |
| $S_{10}$ Hexanal dip (1% conc.) for 4 minutes | 71.61 | 28.27 | 15.73 | 12.64 | 9.15 | 5.12 | 2.85 | 1.17 |
| $S_{11}$ Hexanal dip (1.5% conc.) for 4 minutes | 68.31 | 24.92 | 11.5 | 8.5 | 5.5 | 3.7 | 1.9 | 0.85 |
| $S_{12}$ Hexanal dip (2% conc.) for 4 minutes | 67.65 | 20.13 | 9.54 | 6.83 | 3.62 | 2.46 | 1.37 | 0.52 |
| **SEm±** | **0.15** | **0.54** | **0.53** | **0.93** | **0.99** | **0.69** | **0.43** | **0.24** |
| **C.D. (P=0.01)** | **0.59** | **2.11** | **2.09** | **3.66** | **3.90** | **2.73** | **1.68** | **0.96** |

**Table 5. Effect of hexanal formulation on hunter colour value of pulp a*of custard apple**

| Ambient storage (days) → / Treatments ↓ | Hunter colour value of pulp a* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **0** | **2** | **4** | **6** | **8** | **10** | **12** | **14** |
| $S_0$ Control | -12.77 | -4.57 | -1.67 | -1.02 | 0.52 | 1.49 | 2.16 | 2.86 |
| $S_1$ Hexanal vapour (Filter paper dip in 0.005% conc.) | -12.73 | -10.97 | -5.86 | -3.25 | -1.98 | 0.17 | 0.97 | 1.55 |
| $S_2$ Hexanal vapour (Filter paper dip in 0.01% conc.) | -11.19 | -10.50 | -7.53 | -4.57 | -3.07 | -1.08 | 0.04 | 1.02 |
| $S_3$ Hexanal vapour (Filter paper dip in 0.02% conc.) | -13.20 | -12.66 | -10.40 | -8.87 | -6.28 | -6.10 | -3.85 | 0.54 |
| $S_4$ Hexanal vapour (Filter paper dip in 0.05% conc.) | -13.85 | -13.40 | -13.12 | -12.75 | -11.18 | -9.13 | -7.23 | -3.36 |
| $S_5$ Hexanal dip (0.5% conc.) for 2 minutes | -12.87 | -12.65 | -12.07 | -11.72 | -10.36 | -7.17 | -5.97 | -1.86 |
| $S_6$ Hexanal dip (1% conc.) for 2 minutes | -12.63 | -9.98 | -7.28 | -5.55 | -3.03 | -1.86 | 0.57 | 0.96 |
| $S_7$ Hexanal dip (1.5% conc.) for 2 minutes | -11.84 | -5.00 | -1.53 | -1.03 | 0.06 | 0.26 | 0.75 | 1.01 |
| $S_8$ Hexanal dip (2% conc.) for 2 minutes | -9.18 | -4.49 | -1.72 | -1.14 | 0.19 | 0.47 | 0.89 | 1.18 |
| $S_9$ Hexanal dip (0.5% conc.) for 4 minutes | -12.83 | -3.16 | -2.23 | -1.57 | 0.05 | 0.85 | 1.15 | 1.63 |
| $S_{10}$ Hexanal dip (1% conc.) for 4 minutes | -11.91 | -3.92 | -2.94 | -1.37 | 0.54 | 1.00 | 1.50 | 2.23 |
| $S_{11}$ Hexanal dip (1.5% conc.) for 4 minutes | -11.60 | -2.45 | -1.90 | 0.06 | 0.80 | 1.66 | 2.36 | 3.03 |
| $S_{12}$ Hexanal dip (2% conc.) for 4 minutes | -12.68 | -2.19 | -1.40 | 0.79 | 0.97 | 1.48 | 2.67 | 3.22 |
| **SEm±** | **0.03** | **0.03** | **0.06** | **0.05** | **0.07** | **0.19** | **0.13** | **0.04** |
| **C.D. (P=0.01)** | **0.14** | **0.14** | **0.27** | **0.20** | **0.29** | **0.78** | **0.50** | **0.15** |

**Table 6. Effect of hexanal formulation on hunter colour value of pulp b* of custard apple**

| Ambient storage (days) → / Treatments ↓ | Hunter colour value of pulp b* | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **0** | **2** | **4** | **6** | **8** | **10** | **12** | **14** |
| $S_0$ Control | 9.45 | 20.50 | 28.82 | 37.75 | 46.10 | 39.31 | 26.73 | 13.80 |
| $S_1$ Hexanal vapour (Filter paper dip in 0.005% conc.) | 11.12 | 17.75 | 22.15 | 24.75 | 33.67 | 35.36 | 41.10 | 28.97 |
| $S_2$ Hexanal vapour (Filter paper dip in 0.01% conc.) | 10.09 | 15.66 | 21.13 | 28.63 | 33.77 | 38.68 | 41.44 | 35.98 |
| $S_3$ Hexanal vapour (Filter paper dip in 0.02% conc.) | 11.13 | 15.28 | 24.72 | 31.86 | 34.45 | 36.81 | 37.50 | 42.55 |
| $S_4$ Hexanal vapour (Filter paper dip in 0.05% conc.) | 11.69 | 12.84 | 15.70 | 21.85 | 28.47 | 34.63 | 39.72 | 45.17 |
| $S_5$ Hexanal dip (0.5% conc.) for 2 minutes | 10.70 | 13.78 | 25.15 | 28.57 | 33.09 | 35.48 | 38.23 | 42.37 |
| $S_6$ Hexanal dip (1% conc.) for 2 minutes | 9.78 | 13.76 | 27.98 | 29.48 | 35.78 | 38.24 | 43.64 | 40.34 |
| $S_7$ Hexanal dip (1.5% conc.) for 2 minutes | 9.02 | 12.12 | 20.12 | 25.23 | 33.69 | 36.35 | 38.89 | 35.79 |
| $S_8$ Hexanal dip (2% conc.) for 2 minutes | 9.13 | 11.78 | 18.76 | 22.66 | 31.56 | 34.24 | 42.15 | 40.64 |
| $S_9$ Hexanal dip (0.5% conc.) for 4 minutes | 10.64 | 10.62 | 10.76 | 10.97 | 11.03 | 11.37 | 11.58 | 11.82 |
| $S_{10}$ Hexanal dip (1% conc.) for 4 minutes | 10.14 | 10.15 | 10.45 | 10.74 | 10.93 | 11.21 | 11.37 | 11.67 |
| $S_{11}$ Hexanal dip (1.5% conc.) for 4 minutes | 9.76 | 9.78 | 9.85 | 9.92 | 10.05 | 10.23 | 10.52 | 10.72 |
| $S_{12}$ Hexanal dip (2% conc.) for 4 minutes | 9.76 | 9.77 | 9.83 | 9.88 | 10.01 | 10.14 | 10.38 | 10.57 |
| **SEm±** | **0.02** | **0.13** | **0.61** | **1.15** | **0.87** | **0.79** | **0.82** | **0.42** |
| **C.D. (P=0.01)** | **0.09** | **0.49** | **2.40** | **4.54** | **3.43** | **3.10** | **3.21** | **1.66** |

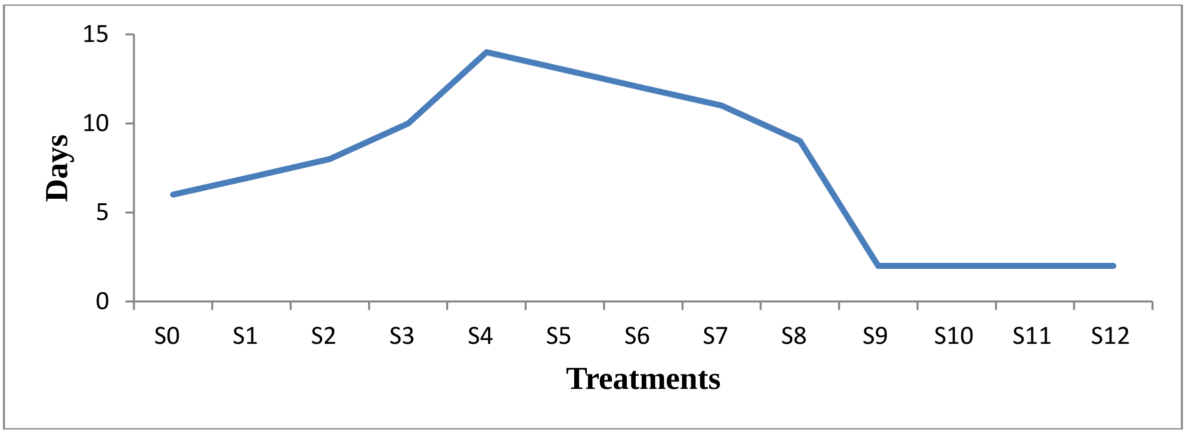


**Fig. 1. Effect of different hexanal formulation on shelf life (Days) of custard apple**

*$S_0$:Control, $S_1$:Hexanalvapour (0.005%), $S_2$ :Hexanalvapour (0.01%), $S_3$:Hexanalvapour ( 0.02% ), $S_4$:Hexanalvapour (0.05%), $S_5$:Hexanal dip (0.5%) for 2 minutes, $S_6$ :Hexanal dip (1 % ) for 2 minutes, $S_7$:Hexanal dip (1.5%) for 2 minutes, $S_8$ :Hexanal dip (2 %) for 2 minutes, $S_9$:Hexanal dip (0.5%) for 4 minutes, $S_{10}$ :Hexanal dip (1 %) for 4 minutes, $S_{11}$:Hexanal dip (1.5%) for 4 minutes, $S_{12}$:Hexanal dip (2 % ) for 4 minutes*

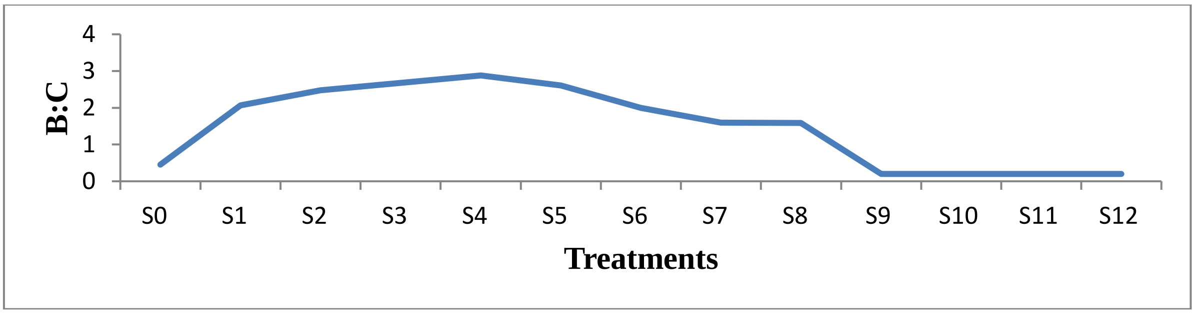


**Fig. 2. Effect of different hexanal formulation on B:Cof custard apple**

*$S_0$:Control, $S_1$:Hexanalvapour (0.005%), $S_2$ :Hexanalvapour (0.01%), $S_3$:Hexanalvapour (0.02%), $S_4$:Hexanalvapour (0.05%), $S_5$:Hexanal dip (0.5%) for 2 minutes, $S_6$ :Hexanal dip (1 % ) for 2 minutes, $S_7$:Hexanal dip (1.5%) for 2 minutes, $S_8$ :Hexanal dip (2 %) for 2 minutes, $S_9$:Hexanal dip (0.5%) for 4 minutes, $S_{10}$ :Hexanal dip (1 %) for 4 minutes, $S_{11}$:Hexanal dip (1.5%) for 4 minutes, $S_{12}$:Hexanal dip (2 % ) for 4 minutes*

## 4. CONCLUSION

Minimizing post harvest losses in custard apple with safe, effective and economical mean is major challenge. Therefore, hexanal vapour (0.05%) which is more effective and easy to use in extending shelf life of custard apple cv. “ArkaSahan”.

## DISCLAIMER

The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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