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OPTIMIZATION OF ETHYLENE CONCENTRATION AND EXPOSURE TIME FOR THE RIPENING OF PAPAYA *VAR. RED LADY* IN FARM LEVEL RIPENING CHAMBE

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ABSTRACT:

A study was conducted to optimize the ethylene concentration and exposure time for the ripening of fruits. Papaya fruit was selected and ripened by applying exogeneous ethylene in a farm level wooden ripening chamber and the ripened fruits were analysed for the quality parameters *viz.*, physiological loss in weight, firmness, colour values, pH, TSS and organoleptic score. The fruits were ripened with three different ethylene concentrations and exposure times viz., 400, 500 and 600 ppm and 15, 20 and 25 hours respectively. The fruits treated with ethylene concentration of 600 ppm for an exposure time of 24 hours fared better with a physiological weight loss percent of 3.88, firmness value of 5.99 Newton, L, a and b value 59.10, 20.22 and 54.10 respectively, pH value of 5.7, TSS value of 14.8 organoleptic score of 8.3. Hence treatment combination of 600 ppm ethylene concentration and exposure time of 24 is optimum for ripening of papaya fruits.

KEY WORDS: *Papaya, Ripening, Ethylene, Ethrel, NaoH.*

INTRODUCTION:

Fruits are classified as either climacteric or non-climacteric based on the pattern of respiration and ethylene biosynthesis during ripening. For climacteric fruits, the respiration rate and ethylene formation are minimum at maturity and rise dramatically to a climacteric peak, at the onset of ripening, after which it declines (Tucker and Grierson, 1987). Examples are papaya, banana, mango, sapota, guava, *etc*.

Papaya (*Carica papaya* L.) is a popular and economically important fruit tree of tropical and subtropical countries. The fruit is consumed world wide as fresh fruit, in the form of vegetable and processed products (Teixeira da Silva *et al.,* 2007). The total production of papaya in India is estimated as 5.3 million tonnes in 2013. It is a climacteric fruit that exhibits a characteristic rise in ethylene production which, in turn, triggers the changes in firmness, aroma and colour.

Ethylene gas is used to initiate and modulate ripening in combination with careful temperature and humidity control. The gas used in ripening rooms is often a mixture of 5 per cent ethylene and 95 per cent nitrogen (Kader, 1992).

Chang and Hwang (1995) reported an increased weight loss in banana fruits due to rise in respiration process caused by ethylene application. Jha *et al*. (2006) conducted a study on mangoes and found that after attaining maturity, the firmness decreased from 32.96 N to 22.39 N due to change in structure of the pectin polymers during ripening in the cell wall. Ethylene treated papayas ripened faster and more uniformly in terms of de-greening, softening and flesh color development. To induce ripening in papaya, fruits must be stored between 18^{o}C and 25^{o}C and treated with ethylene gas at 100 ppm (0.01%) for 24 h. Under this condition, fruit will take 3 to 4 days to develop full yellow skin (An and Paull, 1990).

Thompson (1995) reported that an increase in the content of acids during ripening was followed by a fall in pH from about 5.4 ± 0.3 before the climacteric to about 4.5 ± 0.3 after the climacteric. During ripening the starch content declines from 20 to 23 per cent in unripe fruit and 1 to 2 per cent in fully ripe fruit and at the same time the soluble sugar increases from less than 1 per cent to 20 per cent (Payasi and Sanwal, 2005). So it is important to study the change in physiological weight, firmness, colour values, pH, TSS and organoleptic score and the objective was framed accordingly.

MATERIALS AND METHODS:

The present study was conducted using *Red Lady* variety of papaya. Fully matured papaya fruits were harvested from the Orchard, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. The bruised and diseased fruits were sorted out manually. Only healthy and uniform sized fruits were selected for the study.

Treatments used for ripening of papaya

15 h & 400 ppm

20 h & 400 ppm

25 h & 400 ppm

15 h & 500 ppm

20 h & 500 ppm

25 h &500 ppm

15 h & 600 ppm

20 h & 600 ppm

25 h & 600 ppm

Ripening of fruits

The procedure involved in the ripening of fruits is presented in Fig. 1. An airtight chamber made up of plywood sheet was fabricated with dimensions of 0.6m length, 0.3m width and 0.3m height. A known weight (approximately 5 kg) of freshly harvested unripe cleaned fruits was carefully placed on the tray inside the wooden chamber. The mass and volume of fruits and free volume left in the chamber were recorded. Known quantity of ethrel and NaOH was mixed to produce desired level of ethylene gas. Papaya fruits were exposed to ethylene concentrations of 400, 500 and 600 ppm for three different exposure times of 15, 20 and 24 h. Change in physiological characteristics were observed after the ripening of fruits.

Harvesting of fruits

↓

Cleaning

↓

Ethylene treatment (400, 500 and 600 ppm)

↓

Exposure to ethylene (15, 20 and 25 h)

↓

Ripening

Fig. 1. Process flow chart for ripening of fruits

Physiological loss in weight (PLW)

Fruits were weighed before and after ripening in an electronic balance. Physiological loss in fruit weight was calculated by the formula given below,

$$\text{Physiological loss in weight (per cent)} = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

Colour measurement

Colour flex meter (Model: 45°/0°, M/s Hunter Lab, Reston, Virginia, USA) was used for the measurement of colour. It works on the principle of collecting the light and measures energy from the sample reflected across the entire visible spectrum. The meter uses filters and the mathematical models rely on “standard observer curves” that define the amount of red, green, and blue primary lights required to match a series of colours across the visible spectrum. The mathematical model used is called as Hunter model. It provides reading in terms of L, a, and b. where L indicates whiteness and darkness. Chromatic portion of the solids is defined by: a (red), -a (green), b (yellow), and -b (blue). These data may be sensed from the sensor (colour flex 45°/0°) and it is supported with Universal Software (V4.10) software package. It produces functions that define hue and chroma. ΔL, Δa and Δb value represents the deviations of the individual values of the raw sample from the respective values of the fully ripe sample.

Colour is calibrated by fixing the defined colours like white and black tiles on the colour flex meter. Calibration is performed through necessary changes in the sample. The skin of the fruit was peeled off and it was placed on the colour flex meter and it was then covered with a black cylindrical cup to prevent the reflection of light. Measurement of colour was done as per the above principle by determining 'L', 'a' and 'b' values.

Firmness

The firmness of the raw and ripened fruits was determined using the texture analyzer (M/s.Stable micro system, USA. Model- Texture Expert Version 1.22) as shown in Plate 3.3. The texture analyzer is a microprocessor-controlled system, which is interfaced to a personal computer. It consists of two separate modules, the test-bed and the control console (Keyboard). They are linked by a cable through which low voltage signals and power is routed. The texture analyzer measures force, distance and time, thus providing three dimensional product analysis.

pH value

pH is a measure of the active acidity, which influences the flavour or palatability of a product and affects the processing requirements. The pH value was determined by using a digital pH meter (Systronics µpH system 361, Ahmedabad, India) and it was standardized with distilled water of pH 7.0 and standards at pH 5.0 and 8.5.

Total Soluble Solids

The fruits were pulped using a mixer-grinder. Small samples of the fruit pulp were filtered through muslin cloth and a drop of filtrate was taken to determine the total soluble solids (TSS) using digital hand held pocket refractometer shown in Plate 3.4 (ATAGO, Co Ltd, Japan) and TSS was expressed as ^{o}Brix (Ranganna, 1995).

Organoleptic evaluation

Organoleptic evaluation of the fruits was done by the panel of semi-trained judges for appearance, color, flavor, texture, taste and overall acceptability using 9-point Hedonic scale varying from like extremely (rated as 9) to dislike extremely. These ripened fruits were compared with control and commercially ripened fruits for organoleptic evaluation.

RESULTS AND DISCUSSION:

Number of days for ripening (Attainment of yellow colour)

Treatments	Number of days to attain yellow color (After ethylene exposure)
P_1	5 days
P_2, P_4 and P_7	4 days
P_3, P_5, P_6, P_8 and P_9	3 days

Change in physiological loss in weight

The change in physiological weight of the fruit after ripening is presented in the fig. 3.1. The physiological weight loss in papaya values ranged from 2.77 to 3.88 per cent. It is evident from the Fig.3.1 that the physiological loss in weight increased with increase in ethylene concentration.

This weight loss might be due to the high level of ethylene production and respiration rate leading to rapid and uniform ripening at higher concentrations of ethylene gas. Similar trend was observed during the ripening of banana by (Ahmad and Thompson, 2006).

Change in firmness

The change in firmness of the fruit after ripening is given in the fig. 3.2. The firmness values of all treatments ranged from 5.99 to 22.5 N. It is observed from the Fig 3.2 that the firmness of papaya decreased with increase in exposure time and ethylene concentration. This might be due to the increased effect of degrading enzyme such as polygalacteronase. Similar type of rapid decline in firmness (shear force) values for 'Robusta' fruits were found by Kulkarni *et al.* (2011) and the values were recorded as 79.1 N at 0th day to 53.2 N at 4th day for 500 ppm ethrel treated fruits.

Change in 'L' value

The change in 'L' value of the fruit after ripening is presented in the Fig. 3.3. The 'L' values ranged from 54.63 to 59.10. It is observed from the Fig 3.3 that the 'L' value increased with increase in exposure time and ethylene concentration. Similar results of yellow colour development and later brown spots were observed by Salvador *et al.* (2007) on ripening the papaya fruits.

Change in 'a' value

The change in 'a' value of the fruit after ripening is presented in the Fig. 3.4. The 'a' values ranged from 14.71 to 20.22. It is evident from the Fig 3.4 that the 'a' value increased with increase in exposure time and ethylene concentration. During ripening, the peel color changed from dark green to bright yellow and this is due to the change in chlorophyll which gradually unmasked the carotenoid pigments present in unripe papaya fruits. Similar results were reported by Bal *et al*. (1992) for papaya fruits as the greenness value 'a' increased rapidly to a maximum of 93 and 81 per cent with an ethylene concentrations of 500 and 600 ppm, respectively.

Changes in 'b' value

The change in 'b' value of the fruit after ripening is given in the Fig. 3.5. The 'b' values ranged from 48.60 to 54.10. It is observed from the Fig 3.5 that the 'b' value increased with increase in exposure time and ethylene concentration. This may be due to the breakdown of chlorophyll in the peel. Similar results were reported by Chen and Ramaswamy (2002) for banana.

Change in pH

The change in pH value of the fruit after ripening is given in the Fig. 3.6. The pH values ranged from 5.32 to 5.73. It is observed from the Fig 3.6 that the pH value increased with increase in exposure time and ethylene concentration. Siriboon and Banlusilp (2004) reported similar result for 'Namwa' banana. They reported that the total titrable acid content increased to its peak up to fifth day and started to decline thereafter during the period of ripening.

Change in Total Soluble Solids

The change in TSS value of the fruit after ripening is presented in the Fig. 3.7. The TSS values ranged from 12.6 to 14.8. It is observed from the Fig 3.7 that the total soluble solids value increased with increase in exposure time and ethylene concentration. Increase in Total soluble solids during fruit ripening is due to the hydrolysis of starch to sugars. Similar results were reported by Maini *et al* . (1985) for apple.

Organoleptic evaluation

Sensory evaluation was conducted for the ripened papaya fruits, and is presented in the Table 1.

The overall acceptability of the ripened fruits ranged between 7.3 and 8.3. The overall acceptability of papaya fruit scored a maximum value of 8.3 using 600 ppm ethylene for an exposure time of 25 h.The overall acceptability of control and commercially ripened fruit was 6.5 and 6.2 respectively.

CONCLUSION:

Papaya fruits were ripened with the use of exogenous ethylene in a wooden chamber for three different exposure times of 15, 20 and 25 hours with ethylene concentrations of 400, 500 and 600 ppm. Physico chemical changes were observed for the ripened fruits. It is observed from the results that the fruits ripened with the ethylene concentration of 600 ppm for an exposure time of 25 hours found acceptable in quality wise.

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Table 1. Effect of exposure time and concentration of ethylene on the organoleptic score of papaya fruits

Parameters	Experiment										
	P_1	P_2	P_3	P_4	P_5	P_6	P_7	P_8	P_9	Control	Commercially ripened
Appearance	7.2	7.3	7.4	7.6	7.7	7.8	7.8	8.2	8.3	6.5	6.3
Colour	7.2	7.4	7.5	7.5	7.7	7.9	8.0	8.2	8.4	6.4	6.2
Texture	7.3	7.4	7.4	7.5	7.6	7.7	7.8	8.0	8.2	6.5	6.2
Flavour	7.3	7.4	7.5	7.6	7.7	7.7	7.9	8.1	8.3	6.5	6.2
Taste	7.3	7.3	7.4	7.5	7.6	7.7	7.8	8.2	8.3	6.4	6.1
Overall acceptability	7.3	7.4	7.4	7.5	7.7	7.7	7.9	8.2	8.3	6.5	6.2

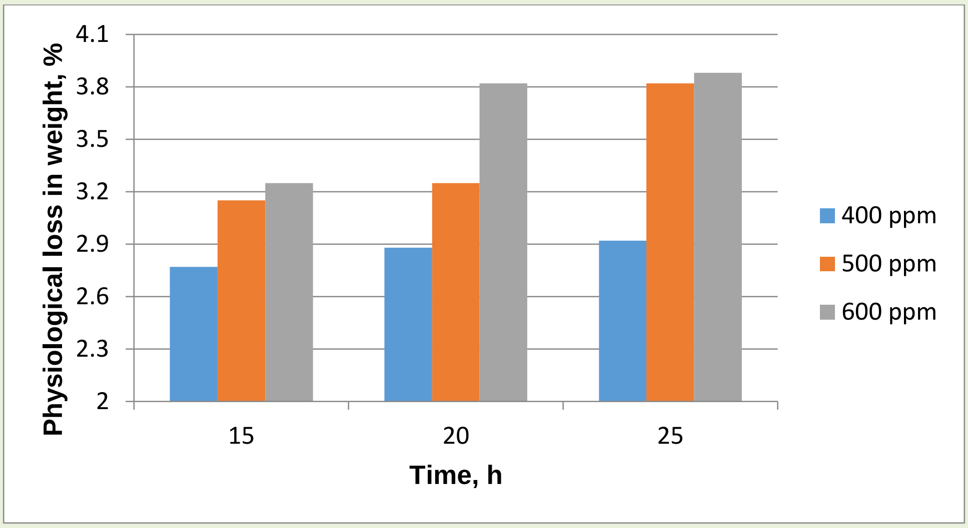

Fig. 1. Effect of exposure time and concentration on physiological loss in weight of papaya

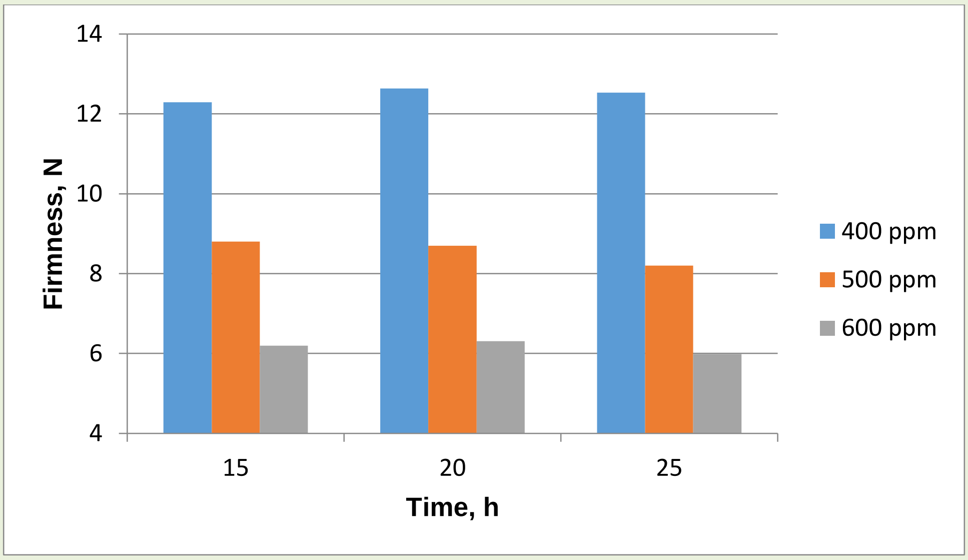

Fig. 2. Effect of exposure time and concentration on firmness of papaya

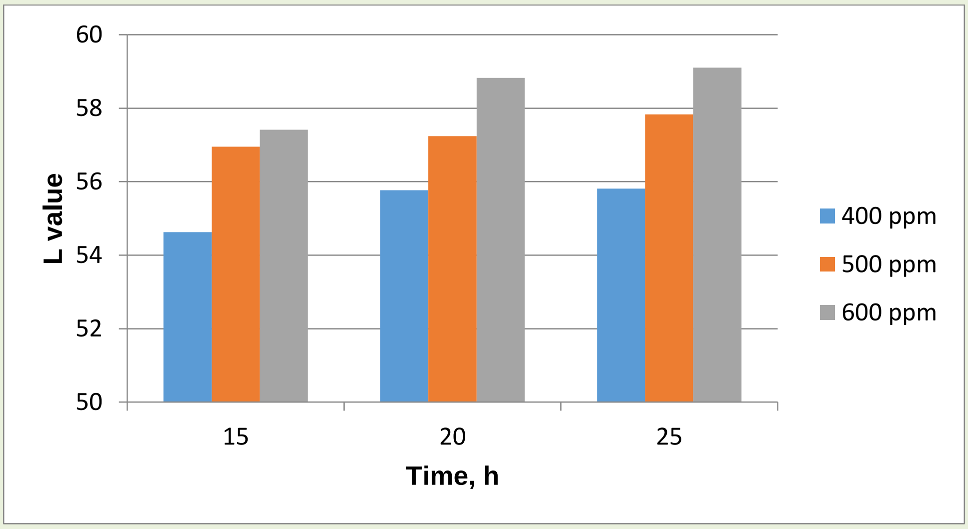

Fig. 3. Effect of exposure time and concentration on 'L' value of papaya

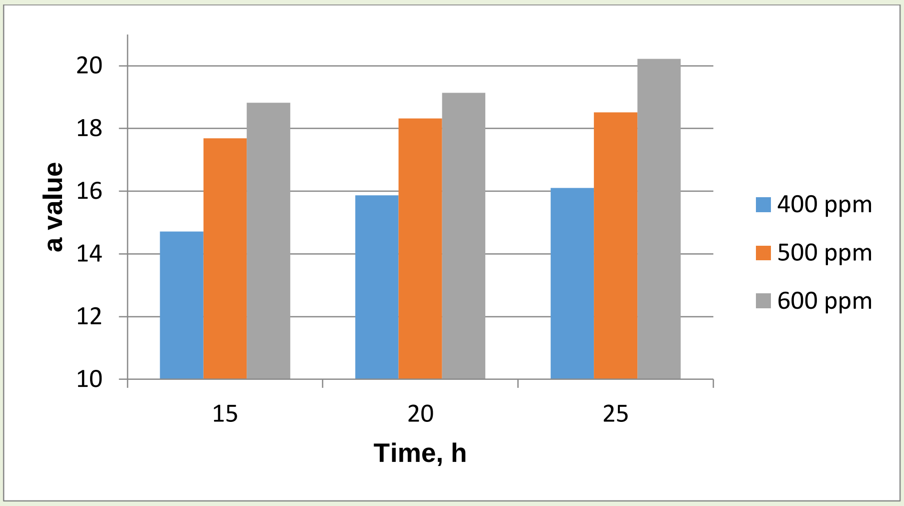

Fig. 4. Effect of exposure time and concentration on ‘a’ value of papaya

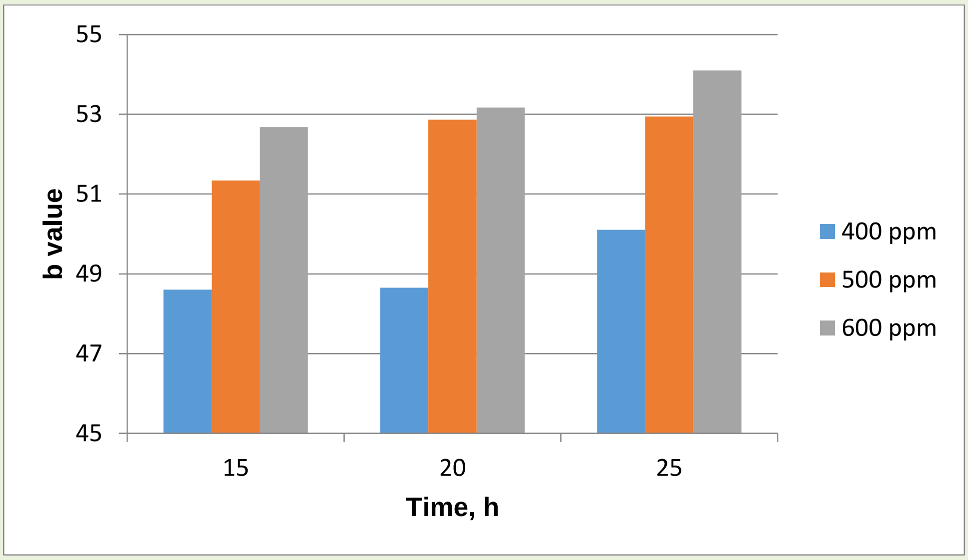

Fig. 5. Effect of exposure time and concentration on ‘b’ value of papaya

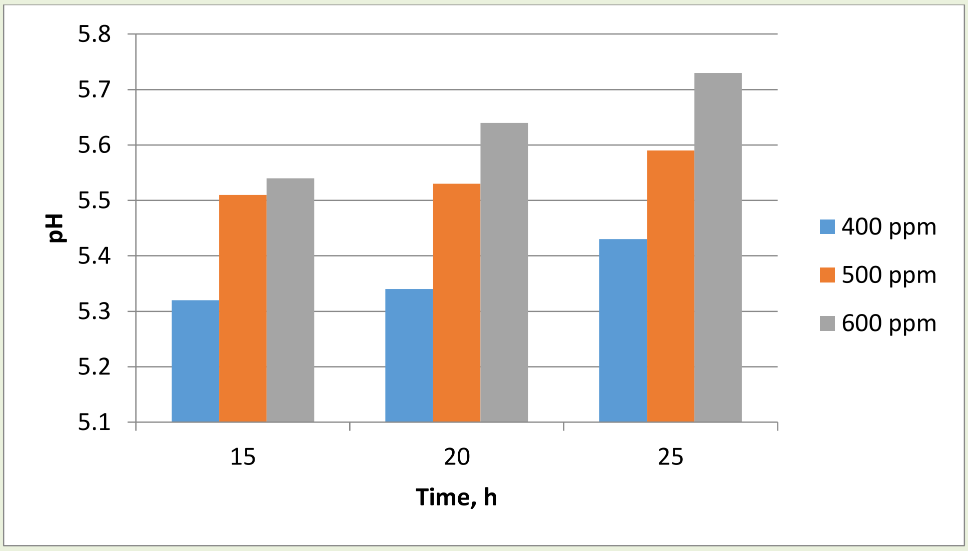

Fig. 6. Effect of exposure time and concentration on pH value of papaya

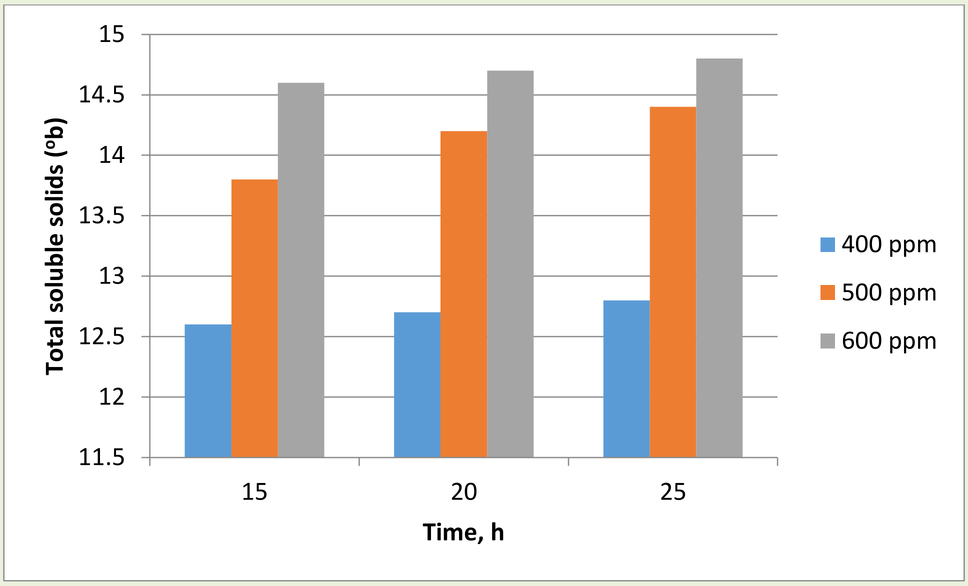

Fig. 7. Effect of exposure time and concentration on TSS value of papaya