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Effect of postharvest treatments on shelf life, visual colour change and biochemical quality of banana variety Poovan

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Abstract
A study was conducted in Karunya Institute of Technology and Sciences, Coimbatore to find the best postharvest treatment to enhance the shelf life of banana var. Poovan by maintaining better biochemical qualities. Fruit bunches were harvested at mature green stage, separated into hands, precooled and subjected to 12 treatments and stored in Corrugated Fibre Board boxes till the end of shelf life under ambient condition. The results from the present study indicated highest shelf life of 20.67 days for fruits dipped in 30ppm sodium hypochlorite (T_2) with least colour change and maximum vitamin C (7.39 mg 100 g^{-1}) at the end of storage. Highest TSS of 25.27°Brix and total sugar content of 21.08% was recorded in fruits coated with 40% aloe vera extract + packaging with potassium permanganate (T_{10}). Fruits wrapped using cling flim showed maximum reducing sugars (13.37%), carotenoids (5.36 µg 100 g^{-1}) and sugar acid ratio (54.23) and fruits treated with 2% hexanal gave maximum acidity of 0.56%.

Keywords: CFB box, hexanal, potassium permanganate, shelf life, sodium hypochlorite

Introduction
Banana (*Musa* sp.) fairly rich in carbohydrates, phenols, dietary fibre and minerals like potassium and calcium are the most sought after fruit in India. With an annual production of 33061.79 MT, India is the largest producer as well as exporter of banana in the world (GoI 2021). Even though it is valued for its nutritional qualities, market gluts which occurs during season, causes severe postharvest loss and as a result farmers are not getting remunerative price for their produce. A postharvest loss to the tune of 2.90% of total farm produce is reported in banana by Kumari and Kumar, (2018) [10]. Hence it is high time to develop technologies for extending the shelf life of banana fruits which is highly perishable due to its climacteric nature. Banana variety Poovan have been selected for the research work since it is the commercial variety of Tamil Nadu and produced year round in large quantities.
Ashwini *et al*. (2018) [4] reported a reduced respiration rate as well as loss of firmness in banana var. Grand Naine upon treatment with hexanal. Due to powerful oxidizing properties, chlorine is found to be a potent disinfectant and sodium hypochlorite is the most widely used form for surface sterilization of fruits. Banana fruits treated with sodium hypochlorite showed significantly minimum Physiological Loss in Weight (PLW), minimum total soluble solids and respiration rate after six days of storage when compared to control (Netravati *et al*., 2018) [25].
According to Kumah *et al.* (2020) [9] beewax treatment of banana var. Mysore prolonged the shelf life of fruits for 10 days compared to control, with minimal weight loss and reduced Total Soluble Solids (TSS). Increased shelf life as well as reduced PLW and fruit spoilage percentage was observed in Red Banana fruits with the application of clove oil, which is a good source of antifungal compound (Venkatesan and Manesha, 2020) [22]. The aloe vera coating which acts as a secondary skin for fruits will helps in reducing the respiration rate and slow down the process of ripening and showed a reduced PLW and increased storage life of banana var. Robusta upto 12 days compared to control (Kumar and Bhatnagar, 2015) [26]. Kaka *et al*. (2019) [27] reported that banana variety Basari treated with hot water treatment maintained highest moisture content, firmness and quality parameters with minimal loss. Many studies have also reported that fruits treated with hot water maintained the fruit quality with better shelf life. Banana var. Champa fruits packed with an ethylene scavenger, $KMnO_4$ showed highest TSS with a shelf life of 10 days compared to control (Akter *et al*., 2013) [2].

Materials and Methods

Bunches of banana variety Poovan bought from Booluvampatti market, Coimbatore were used for the study, which was carried out in Horticulture lab, School of Agricultural Sciences, Karunya Institute of Technology and Sciences, Coimbatore during the year 2022-23. Fruits harvested at mature green stage (80% maturity) with uniform size, shape, colour without any damage were taken and the bunches were separated into hands after cleaning and precooling (hydro cooling) was given to reduce the field heat. Further they were subjected to different postharvest treatments and packaged in Corrugated Fibre Board (CFB) boxes and stored till the end of shelf life at ambient conditions to study the effect on shelf life, visual colour change and biochemical parameters.

Three boxes with three hands each were kept in a treatment.

Table 1: Treatment details

	Treatments details
T_1	2% Hexanal (dipping)
T_2	Dipping in 30ppm sodium hypochlorite solution
T_3	Coating with 10% Bee wax
T_4	Coating with 10% Bee wax + 0.5% Clove oil
T_5	Coating with 40% aloe vera extract
T_6	Cling film wrapping
T_7	Hot water dipping at 50 °C for 10 minutes
T_8	Potassium permanganate *(6 g $KMnO_4$ per seven fingers of banana fruits as sachets)
T_9	Coating with 10% Bee wax + potassium permanganate*
T_{10}	Coating with 40% aloe vera extract + potassium permanganate*
T_{11}	Hot water dipping at 50 °C for 10 minutes + potassium permanganate*
T_{12}	Control

Shelf life

Shelf life of banana variety Poovan as influenced by different post-harvest treatments were calculated by counting the number of days required to ripe the fruits fully as to retain optimum marketing and eating qualities.

Visual colour change

Colour of banana peel has been used in the assessment of the stages of ripening in banana. Commercial standard colour charts for banana was developed by Tapre and Jain (2012), with 7 stages of peel colour which was transformed to a numerical scale where, stage 1 - All green, stage 2 - Green with trace of yellow, stage 3 - More green than yellow, stage 4 - More yellow than green, stage 5 - Yellow with trace of green, stage 6 - Full yellow and stage 7 - Full yellow with brown spots.

Biochemical parameters

Total soluble solids (° Brix)

Total soluble solids (TSS) content of banana fruit pulp were estimated using digital refractometer (Model - MA 871) and expressed in degree brix (A.O.A.C, 1980).

Titratable acidity (%)

The titrable acidity was estimated by titrating with 0.1 N sodium hydroxide (NaOH) solution using phenolphthalein as an indicator and expressed as per cent of malic acid. A known weight of fruit was ground using distilled water and made upto 100 ml in a standard flask. An aliquot of 10 ml from this was titrated against 0.1 N NaOH (Ranganna, 1997) [28].

$$\text{Acidity} = \frac{\text{Normality} \times \text{Titre value} \times \text{Equivalent weight} \times \text{Volume made up} \times 100}{\text{Weight of sample} \times \text{Aliquot of sample} \times 1000}$$

Vitamin C (mg 100 g^{-1})

Five grams of the fruit was taken and extracted with four per cent oxalic acid. Ascorbic acid was estimated by using standard indicator dye 2,6- dichlorophenol indophenol and expressed as mg 100 g^{-1} of fruit (Sadasivam and Manickam, 1996) [17].

Total Sugars (%)

Total sugar content of banana pulp was determined calorimetrically by anthrone method (Jayaraman, 1981) [7] using anthrone reagent and expressed in percentage.

Reducing sugars (%)

Reducing sugar content of banana pulp was determined by dinitrosalicylic acid method (Miller, 1959) [12].

Total carotenoids (µg 100 g^{-1})

Take 100 mg of fresh sample and add to it 10 ml of 80% acetone and grind it well in a mortar and pestle and centrifuge it at 3000 rpm for 10 mins. Take the supernatant and discard the pellet. Make up the supernatant upto a known volume of 10 ml and read the OD values at 480 nm in UV-spectrophotometer (Jensen, 1978) [8].

Sugar: acid ratio

The total amount of sugars can be divided with the acidity content to find the sugar acid ratio present in the banana fruit.

Statistical analysis

The data was analysed statistically by applying the techniques of analysis of variance (Panse and Sukhatme, 1985) [16].

Results and Discussion

Shelf life

The observation on shelf life of banana variety Poovan subjected to different post-harvest treatments showed significant differences among the treatments in the present study (Table 2). Highest shelf life of 20.67 days was noticed in T_2 (Dipping in 30 ppm sodium hypochlorite solution) (Fig. 1) which was on par with T_6 (Cling film wrapping), T_7 (Hot water dipping at 50 °C for 10 minutes), T_3 (Coating with 10% Bee wax) and T_8 (Potassium permanganate). Lowest shelf life (14.67 days) was observed in T_{12} (Control) (Fig. 2) which was found to be on par with T_1 (dipping in 2% Hexanal). Surface sterilization using sodium hypochlorite might have reduced the microbial load in the fruit surface which there by increased the shelf life. Nasrin *et al.* (2008) [15] reported a shelf life of 17 days in tomato variety Lalima on treatment with chlorine which is in consonance with the present study. Increased shelf life of banana cv. Sabri upon treatment with hot water at 45 °C for 2 minutes and packaging with potassium permanganate was reported by Siddiqua *et al.* (2018) [19] and Akter *et al.* (2013) [2] respectively. Coating with bee wax prolonged the shelf life in banana variety Mysore (Kumah *et al*., 2020) [9]. Lowest shelf life in control was reported by Muthuvel *et al.* (2019) in banana variety Poovan.

Visual colour change

On 3rd day of storage T_1 (2.67) and T_{12} (2.33) was found to

have highest value for visual colour change and the lowest score was observed in all the other treatments T_2, T_3, T_4, T_5, T_6, T_7, T_8, T_9, T_{10}, T_{11} (1.00) (Table 2). On 6th day of storage highest value was found in T_5 (5.67) which was on par with T_{10} (5.33) and the lowest value was observed in T_6 (1.67) which was on par with T_2 (2.00) and T_8 (2.33). Highest value for visual colour change on 9th day of storage was observed in T_{12} (6.67) which was on par with T_3, T_{10} and T_{11} (6.00) and lowest value was observed in T_2 (2.33) and T_6 (2.67). T_1, T_5, T_{12} (7.00) showed highest score for visual colour change on 12th day of storage which was on par with T_3, T_6, T_9 (6.33), T_{10}, T_{11} (6.00) and the least value was seen in T_2 and T_4 (4.33). On 15th day of storage the higher mean value was observed in T_1, T_3, T_5, T_9, T_{11} (7.00), T_2, T_6, T_{10} (6.66), T_8 (6.00) which is on par with T_7 (6.00) and and the lowest was on T_4 (5.00) which is on par with T_7 (6.00).

Total soluble solids (° Brix

The TSS content was found to be 12.3° Brix initially and it increased gradually in all the treatments during storage in CFB box under ambient condition (Table 3). Highest TSS of 26.4°Brix was observed in T_{12} after 14.67 days of storage, which was found to be on par with T_{10} (coating with 40% aloe vera extract + potassium permanganate) and T_4 (coating with 10% Bee wax + 0.5% clove oil) with 25.2°Brix after 16.67 days and 24.4°Brix after 19 days respectively. T_1 (2% Hexanal) registered lowest TSS of 20.73°Brix after 15.67 days which was found to be on par with T_{11} (Hot water dipping at 50 °C for 10 minutes + potassium permanganate) with 21.5°Brix after 16.67 days and T_3 (coating with 10% bee wax) with 21.9°Brix after 19.33 days. In the study, TSS was found to be increasing in all the treatments during the storage due to conversion of starch to sugars (Mohapatra *et al*., 2016) [13]. Ashwini *et al*. (2018) [4] reported higher TSS in control after nine days of storage when compared with different hexanal treated fruits of banana var. Grand Naine which was found to be in consonance with the present study. According to Quoc (2021) [11] the TSS content of aloe vera coated Pisang Awak banana fruits was found to be significant compared to control. Yumbya *et al*. (2018) [24] concluded that hexanal treatment significantly reduced the rate of TSS of banana var. Grand Naine when compared with control, which is in consonance with the present study. Studies on hot water treatment of mango cv. Sindhri fruits showed lowest development of TSS compared to control (Anwar *et al*., 2007) [3].

Titratable acidity

Titratable acidity of banana var. Poovan fruits was analysed during the initial stage and at the end of the storage (Table 3). During the initial stage the malic acid content was 4.56% in all the treatments and it was found to decrease after storage. Statistical analysis of titratable acidity done at the end of shelf life showed highest acidity (0.56%) in T_1 after 15.67 days of storage which was found to be on par with T_9 (0.54%) after 13.33 days and lowest acid content of 0.39% was noticed in T_5 and T_6 on 19th and 20.33 days of storage respectively. The reduction in acidity of fruits during storage period is due to the convertion of organic acids into sugars. Kumah *et al*. (2020) [9] reported that banana variety Mysore treated with beewax shows increased titratable acidity as ripening progresses which was found to be in consonance with the present study. Coating of Pisang awak banana fruits with *aloe vera* extract reduced acidity towards the end of shelf life (Quoc, 2021).

Vitamin C

The observations on vitamin C content of banana variety Poovan at initial stage was 2.73 mg 100 g^{-1} and it showed significant difference among treatments at the end of shelf life (Table 3). Highest vitamin C content was observed in fruits treated with hot water dipping at 50 °C for 10 minutes (T_7) with 7.94 mg 100 g^{-1} after 20.33 days and lowest was recorded in T_8 (6.36 mg 100 g^{-1}) and T_9 (6.35 mg 100 g^{-1}) after 19.33 days and 17.33 days of storage respectively. Siddiqua *et al*. (2018) [19] reported that banana cv. Sabri treated with hot water treatment showed least reduction in vitamin C content. Bee wax coating in sweet orange cv. Blood Red fruits showed minimum vitamin C content after 56th day of storage which is due to the oxidation of ascorbic acid which results in the formation of dehydroascorbic acid (Shahid *et al*., 2011) [18].

Total Sugars

The total sugars of banana var. Poovan was found to be non-significant among the treatments in the present study (Table 3). Initial total sugar content was 7.52% in all the treatments and at the end of storage, highest value was observed in T_{10} (21.08%) and T_8 registered lowest value (19.72%).

Reducing sugars

The reducing sugar content in banana var. Poovan at initial stage was 2.73% and at the final stage significant difference was noted among the treatments (Table 3). Highest value was recorded in T_{12} with 15.98% on 14.67 days of storage and lowest was found in T_2 (11.29%) on 20.67 days of storage, which was found to be on par with T_{10} (11.74%) and T_9 (coating with 10% bee wax + potassium permanganate) with 12.24% which was recorded on 16.67 and 17.33 days of storage respectively. The increase in the reducing sugar content of banana fruits during ripening can be due to hydrolysis of starch into soluble sugars. Hailu *et al.* (2012) [6] reported that the reducing sugar content was higher in control as the process of ripening hastens in untreated fruits of banana. According to Quoc (2021) [11], reducing sugar content was found to be minimum in *Aloe vera* coated Pisang Awak banana fruits. As per Kaur *et al*. (2018) minimum reducing sugars were observed in banana cv. Grand Naine fruits stored with $KMnO_4$, and the effect was found to be due to ethylene scavenging activity of $KMnO_4$ which leads to reduced ripening.

Total carotenoids

The total carotenoids in banana var. Poovan was found to be non-significant among the treatment in the present study (Table 3). Initially the total carotenoids was 0.95 µg 100 g^{-1} in all the treatments and at the end of the storage period, highest value was observed in T_9 (5.99 µg 100 g^{-1}) and the lowest was recorded in T_6 (5.36 µg 100 g^{-1}).

Sugar: acid ratio

Initial observations on sugar: acid ratio was 1.65 and at the end of the storage period it was found to be significant in all the treatments (Table 3). Highest was observed on 20.33 days in T_6 (54.23) which is on par with T_5 (51.22) and T_4 (48.03) on 19 days of storage and the lowest was noticed on T_1 and T

9 after 15.67 and 17.33 days with 35.51 and 37.69 respectively. The sugar content rises as the fruit ripens, the fruit acids deteriorate and the sugar-acid ratio rises in value. The main reason for the rise in the sugar-acid ratio level may be related to the ripening which is induced by the breakdown of starch into water, soluble sugars, sucrose, and glucose.

Table 2: Effect of different postharvest treatments on shelf life and visual colour change of banana variety Poovan

Treatments	Shelf life (days)	Visual colour change					
		3rd day	6th day	9th day	12th day	15th day	18th day
T_1	15.67	2.66	4.33	5.00	7.00	7.00	-
T_2	20.67	1.00	2.00	2.33	3.33	6.67	7.00
T_3	19.33	1.00	4.33	6.00	6.33	7.00	7.00
T_4	19.00	1.00	3.00	4.33	4.33	5.00	6.00
T_5	19.00	1.00	5.67	5.76	7.00	7.00	7.00
T_6	20.33	1.00	1.67	2.67	6.33	6.67`	6.66
T_7	20.33	1.00	2.67	5.00	5.67	6.00	7.00
T_8	19.33	1.00	2.33	4.67	6.00	6.33	6.66
T_9	17.33	1.00	2.67	5.67	6.33	7.00	-
T_{10}	16.67	1.00	5.33	6.00	6.00	6.67	-
T_{11}	16.67	1.00	5.33	6.00	6.00	7.00	-
T_{12}	14.67	2.33	3.67	6.667	7.00	-	-
SE (±)	0.48	0.36	0.35	0.50	0.37	0.36	NS
C.D (0.05)	1.40	0.39	1.01	1.486	1.088	1.063	NS

Table 3: Effect of different postharvest treatments on Biochemical parameters of banana variety Poovan

Treatments	TSS (°Brix)		Titratable acidity (%)		Vitamin C (mg 100 g^{-1})		Total sugars (%)		Reducing sugars (%)		Total carotenoids (µg 100 g^{-1})		Sugar acid ratio	
	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final	Initial	Final
T_1	12.3	20.73	4.56	0.56	2.73	7.29	7.52	19.95	2.73	13.33	0.95	4.50	1.65	35.51
T_2		21.97		0.47		7.39		21.02		11.29		4.53		44.55
T_3		21.67		0.44		7.25		20.31		12.44		4.65		45.48
T_4		24.47		0.43		6.97		20.80		12.53		4.73		48.03
T_5		22.43		0.39		7.45		20.11		12.43		4.72		51.22
T_6		22.70		0.39		7.33		20.95		13.37		5.36		54.23
T_7		23.60		0.45		7.94		20.35		13.28		5.14		45.49
T_8		22.73		0.43		6.36		19.71		14.05		5.20		45.54
T_9		22.06		0.53		6.35		20.22		12.24		5.99		37.69
T_{10}		25.27		0.47		6.97		21.08		11.74		4.96		44.62
T_{11}		21.50		0.44		6.99		20.83		12.71		5.19		47.34
T_{12}		26.40		0.51		7.26		20.61		15.97		5.45		40.18
SE (±)		4.20		0.10		0.81		NS		0.58		NS		2.27
C.D (0.05)		2.50		0.06		0.48		NS		1.69		NS		6.65

Fig 1: T_2 (Dipping in 30ppm sodium hypochlorite solution) fruits of Poovan after 20.67 days

Fig 2: T_{12} (Control) fruits of Poovan after 20.67 days

Conclusion

The present study found highest shelf life of 20.67 days with higher vitamin C content (7.39 mg 100 g^{-1}) in banana var. Poovan fruits, harvested at mature green stage, precooled, dipped in 30ppm sodium hypochlorite and stored in Corrugated Fibre Board boxes till the end of shelf life under ambient condition. Therefore, surface sterilization with 30 ppm sodium hypochlorite can be suggested to increase the shelf life of banana var. Poovan fruits.

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References

1. Ahmed Z, Miano TF, Miano TF. Potassium permanganate ($KMnO_4$) in relation to temperatures alters shelf life and quality of banana (*Musa paradisiaca*

L.). culture. 2021;5(1):41-51.
2. Akter H, Hassan MK, Rabbani MG, Mahmud AA. Effects of variety and postharvest treatments on shelf life and quality of banana. Journal of Environmental Science and Natural Resources. 2013;6(2):163-175.
3. Anwar R, Malik AU. Hot water treatment affects ripening quality and storage life of mango (*Mangifera indica* L.). Pakistan Journal of Agricultural Sciences. 2007;44(2):304-311.
4. Ashwini T, Ganapathy S, Subramanian KS, Rani CI, Meenakshi GG. Effect of Hexanal vapour on postharvest quality and shelf life of banana var. Grand Naine. International Journal of Current Microbiology and Applied Sciences. 2018;7(2):2441-2450.
5. Calberto G, Staver C, Etten JV, Molina AB. Banana growers facing climate change in Asia and the Pacific: Planning adaptation to uncertainty, weather variability and extreme events. International banana symposium, Kaohsiung city, Taiwan, Republic of China; c2012.
6. Hailu M, Workneh TS, Belew D. Effect of packaging materials on the quality of banana cultivars. African Journal of Agricultural Research. 2012;7(7):1226-1237.
7. Jayaraman J. Laboratory manual in Biochemistry. Wiley Estern Ltd. New Delhi, India; c1981.
8. Jensen A, Chlorophylls and carotenoids. In: Handbook of Phycological Methods: Physiological and Biochemical Methods; Hellebust, J.A., Craigie, J.S., Eds.; Cambridge University Press: Cambridge, UK; c1978. p. 59–70.
9. Kumah P, Tandoh PK, Konadu KS. Effect of Different Waxing Materials on the Quality and Shelf Life of Mysore Banana Variety. 2020;12(1):1-11.
10. Kumari P, Kumar S. A study on post-harvest losses and constraints in banana cultivation in Vaishali district (Bihar). The Pharma Innovation Journal. 2018:7(6):93-95.
11. Le Pham Tan QUOC. Effect of Aloe vera Gel Coating on the Quality of Banana Fruit During Storage. Bulletin of the Transilvania University of Brasov, Series II. Forestry, Wood Industry, Agricultural Food Engineering. 2021, 14(2).
12. Miller GL. Use of dinitrosalicylic acid reagent for determination of reducing sugar. Analytical Chemistry 1959;31:426
13. Mohapatra A, Yuvraj BK, Shanmugasundaram S. Physicochemical changes during ripening of red banana. International Journal of Science, Environment and Technology. 2016;5(3):1340-1348.
14. Muthuvel I, Srivignesh S, Mutharasu P, Kavino M, Subramanian KS. Shelf Life Extension of Banana (*Musa* spp.) using Hexanal Formulation as a Post-harvest Dip. 38(6):1-12.
15. Nasrin TAA, Molla MM, Hossaen MA, Alam MS, Yasmin L. Effect of postharvest treatments on shelf life and quality of tomato. Bangladesh Journal of Agricultural Research. 2008;33(4):579-585.
16. Panse, VG, Sukhatme PV. Statistical Method for Agricultural Workers. Indian Council of Agricultural Research, New Delhi. 1985. p. 347.
17. Sadasivam S, Manikam A. Biochemical Methods. (92nd Ed.). New Age International Publishers, 1996. p. 256.
18. Shahid MN, Abbasi NA. Effect of bee wax coatings on physiological change in fruits of sweet orange cv. Blood Red. Sarhad Journal of Agriculture. 2011;27(3):385-394
19. Siddiqua M, Khan SAKU, Tabassum P, Sultana S. Effects of neem leaf extract and hot water treatments on shelf life and quality of banana: Effect of plant extract and hot water on banana. Journal of the Bangladesh Agricultural University. 2018;16(3):351-356.
20. Srivastava MP, Tandon RN. Influence of temperature on Botrydiplodia rots of citrus and sapodilla. Indian Phytopath. 1968;21:195-197.
21. Tapre AR, Jain RK. Studies of advanced maturity stages of banana. International Journal of Advanced Engineering Research and Studies. 2012;1(3):272-274.
22. Venkatesan S, Manesha. Effect of different spice solutions on the shelf life extension of red banana stored at room temperature. Plant achives 2020;20(1):1323-1326.
23. Vinayagamoorthi N, Sekhar C, Palanichamy NV, Sivakumar M. Economic appraisal of different varieties of banana plantations in Central Tamil Nadu. International Research Journal of Agricultural Economics and Statistics. 2019;10(1):34-46.
24. Yumbya PM, Hutchinson MJ, Ambuko J, Owino WO, Sullivan A, Paliyath G, *et al*. Efficacy of hexanal application on the post-harvest shelf life and quality of banana fruits (*Musa acuminata*) in Kenya. Tropical Agriculture; c2018.
25. Mahendra R, Ingle AP, Priti P, Netravati A, Rajendra G, Pramod I. Effective management of soft rot of ginger caused by *Pythium* spp. and *Fusarium* spp.: emerging role of nanotechnology. Applied Microbiology and Biotechnology. 2018;102(16):6827-6839.
26. Pahuja R, Seth K, Shukla A, Shukla RK, Bhatnagar P, Chauhan LK, *et al*. Trans-blood brain barrier delivery of dopamine-loaded nanoparticles reverses functional deficits in parkinsonian rats. ACS nano. 2015 May 26;9(5):4850-71.
27. Kakodkar P, Kaka N, Baig MN. A comprehensive literature review on the clinical presentation, and management of the pandemic coronavirus disease 2019 (COVID-19). Cureus. 2020 Apr 6, 12(4).
28. Ranganna B, Kushalappa AC, Raghavan GS. Ultraviolet irradiance to control dry rot and soft rot of potato in storage. Canadian Journal of Plant Pathology. 1997 Mar 1;19(1):30-35.