DOI : 10.5958/0974-0112.2018.00113.5

Indian J. Hort. 75(4), December 2018: 678-683

Effect of sodium bicarbonate on quality of pear fruits under low temperature storage

Amandeep Kaur*, P. P. S. Gill and S. K. Jawandha
Department of Fruit Science, Punjab Agricultural University, Ludhiana 141 004, Punjab

ABSTRACT

The aim of study was to investigate the effect of sodium bicarbonate on physiochemical and enzymatic changes of 'Patharnakh' pear fruits stored at low temperature. Pear fruits were dipped in different concentrations of sodium bicarbonate (0.0, 1.0, 2.0 and 3.0%) and stored at 0-1^0 C and 90-95% RH for 70 days. Physical and biochemical attributes of the fruits were determined at 0, 20, 40, 60 and 70 days during storage. Exogenous applications of sodium bicarbonate reduced cellulase, PME and PPO enzyme activities. As compared to control, sodium bicarbonate (3%) resulted in 27 per cent higher fruit firmness, 14.3% greater sensory quality and 26.4% higher total phenolics content at 60 days of storage. Furthermore, sodium bicarbonate application effectively retarded the degradation of titratable acidity, ascorbic acid content, weight loss and total soluble solids. Thus, sodium bicarbonate was found to be useful for extending the shelf life and maintaining quality of pear fruits during low temperature storage.

Key words: *Pyrus communis*, sodium bicarbonate, storage, fruit quality, enzyme activity.

INTRODUCTION

Patharnakh is the most important pear cultivar grown in the northwestern arid irrigated parts of India, due to its high yield potential, low chill requirement, adaptation to various biotic and abiotic stresses. The fruits of 'Patharnakh' pear are harvested during the hot and humid monsoon season and are liable to post harvest losses. Under ambient conditions, fruit rapidly lose their market value and shelf-life is limited. After harvesting, biochemical changes underlying quality declines encompass free radical injury, cell wall degradation, oxidative damage, membrane lipid peroxidation, high metabolic activity, moisture loss, high respiration rate and loss of nutritional value. Thus, it is imperative to develop alternative postharvest technologies to maintain overall better pear quality for longer time during transport chain. Globally, a number of postharvest technologies have been developed to control postharvest diseases, maintaining quality of fruits and and minimizes the losses. Various attempts have been made to improve the postharvest life of pear and to store the surplus fruit under low temperature for a longer period to increase its marketability.

Sodium bicarbonate is a novel antifungal agent, inexpensive, readily available and poses lower toxicological risk, plays an important role in controlling the post harvest decay in many fruits. (De Costa *et al.*, 7) reported that spore production and germination, mycelia growth of *Colletotrichum musae* can also be inhibited by sodium bicarbonate. This may be due to change of pH of growth environment for microbes by sodium bicarbonate (Manteau *et al.,* 10). The positive effect of sodium bicarbonate on improving fruit quality leads to delay in respiration process and decay incidences (Palou *et al.*, 11). Therefore, considering the positive effects of sodium bicarbonate compounds on fresh horticultural commodities, the present research was conducted to study the effects of post-harvest treatments of sodium bicarbonate on physico-chemical and enzymatic changes in pear *cv.* Patharnakh during cold storage.

MATERIALS AND METHODS

For the experiment, fruits of pear *cv.* Patharnakh were harvested from the Fruit Research Farm, Department of Fruit Science, Punjab Agricultural University, Ludhiana (India) in the year 2017. The harvested fruits were sorted on the basis of uniformity in size, colour, and absence of visible injury. Selected fruits were dipped for 5 min. in solution of sodium bicarbonate at different concentrations (1, 2 and 3%). Control fruits were dipped in water only. The experiment comprised of four treatments with four replications in each treatment. One kg of fruit from every replication of each treatment was packed in corrugated fibreboard boxes (5 % perforation) with paper lining and kept at 0–1 °C and 90–95 % RH for 70 days. Fruit samples were analysed after 0, 20, 40, 60 and 70 days of storage for various physico-

*Corresponding author's E-mail: amankaur17@pau.edu

chemical characteristics. Firmness of fruits was measured with the help of fruit penetrometer (Model FT-327, Italy). With the help of peeler, about one cm square of peel was removed from the shoulder of fruit and firmness of flesh was recorded and expressed in terms of lbf. Weight loss of fruits was calculated by subtracting final weight from initial weight and expressed in percentage with reference to the initial weight. Sensory evaluation of treated fruits was done by panel of 5 judges. Panelists evaluated the fruit on basis of freshness colour, aroma, texture, taste and overall acceptance according to 9-point scale described by Amerine *et al.* (2). Spoilage (%) was measured as a proportion of rotton fruits weight relative to total weight of fruits within each replication. Total sugars were deliberated by Lane and Eynon's titration method as given by Ranganna (12) and expressed in percentage. The ascorbic acid was estimated by using 2, 6-dichlorphenol-indophenol dye method as described Ranganna (12) and expressed in mg/100ml of juice. Total soluble solids were determined by temperature compensated digital refractometer (ATAGO, PAL-1, Japan) and expressed in °Brix. Titratable acidity was recorded as per AOAC (3) and expressed in percent of malic acid. Total phenolic content was estimated by using Folin- Ciocateu method as described by Singh *et al.,* (14). The PME and cellulase activities were estimated as described by (Mahadevan and Sridhar, 11). PPO activity was estimated as method reported by Serradell *et al.* (13) and expressed in units.mg^{-1}protein. The protein content in enzyme extract was estimated with method given by Bradford (6).

The experiment was set up as per completely randomized design and the data analysis was performed using the Statistical Analysis Software System SAS version 9.3 (SAS Institute, Inc, 1992; Cary, NC, USA). The analysis of variance (ANOVA) was done using PROC GLM. Mean comparisons were performed using LSD test at $p < 0.05$. Results were expressed as means ± standard error.

RESULTS AND DISCUSSION

Fig. 1A shows the weight loss of sodium bicarbonate treated fruits stored at 0-1°C for 70 days. Weight loss of fruits significantly increased from 0 to 70 days of storage regardless of the applied treatments. However, sodium bicarbonate treated fruits showed lower weight loss as compared to untreated fruits. Maximum weight loss of fruits was recorded in untreated fruits and minimum was observed in sodium bicarbonate 3.0% treated fruits. From the 20^{th} day of storage to end of study, the weight loss of fruits increased from 2.69 to 4.94 % in sodium bicarbonate (3.0%) treatment and 3.92 to 6.86% in control fruits. Weight loss of fruits is mainly due to transpiration, respiration and other metabolic activities. Results are also in conformity with findings of El-Eryan and El-Metawally (8) who reported loss in weight of fruits significantly decreased with sodium bicarbonate treatment in 'LeConte' during cold storage In pear, fruit firmness is considered as important physical parameter used to assess the texture, storage life and progression in fruit softening. A decline in fruit firmness was recorded during storage of pear fruits in all the treatments. Fruits treated with sodium bicarbonate exhibited higher fruit firmness as compared to control. At 70^{th} day of storage, the mean fruit firmness of sodium bicarbonate 3% treated fruits was 37.60 % higher than control fruits (Fig. 1B). Similar finding were also reported by El-Eryan and El-Metawally (8). On 20^{th} day of storage, no spoilage was observed in any concentration of sodium bicarbonate; however, untreated fruits exhibited 3.31% spoilage. Spoilage percentage continuously increased during storage. At 70^{th} day, untreated fruits showed 6.34 percent spoilage while spoilage in sodium bicarbonate 3% treated fruit was 4.84% and it was 30.99% lower than untreated fruits (Fig. 1C). Sodium salts are GRAS compounds which are widely used for controlling postharvest decay of horticultural crops. The treatment of sodium bicarbonate gives long term protection and prevents from decay incidence in Blood oranges (Ahmed *et al.,* 1). TA content significantly declined in pear fruits during storage irrespective to the treatments. At 70 days of storage postharvest applications of sodium bicarbonate @ 3% significantly maintained higher level of titratable acidity (0.31%), as compared to untreated fruits (Fig. 1D). The consumption of organic acids in respiratory process might have resulted in reduction in acidity level of fruit.

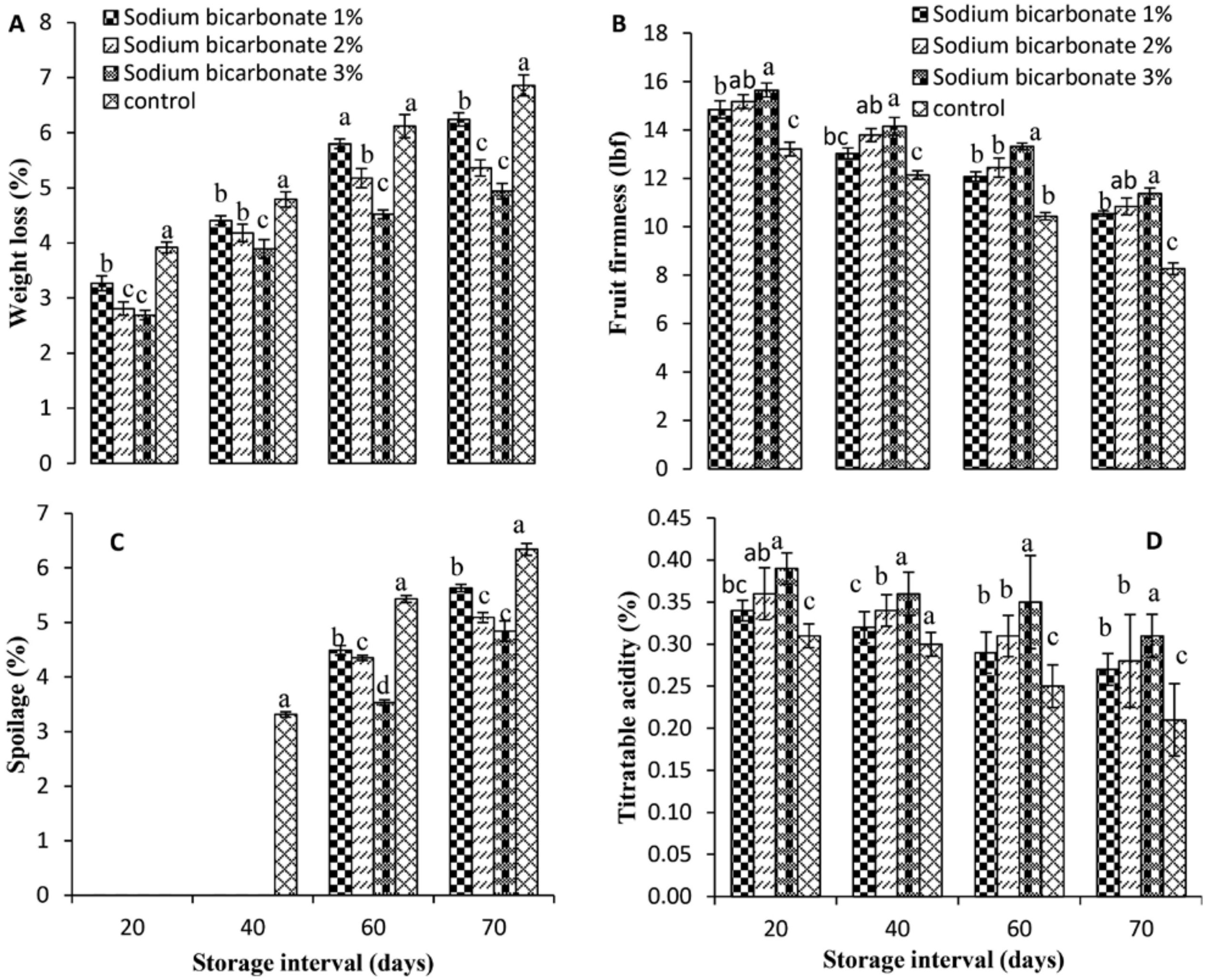
A gradual progression in TSS and total sugars was recorded in all the treatments till 60 days of storage followed by a decline (Table 1). Conversely, ascorbic acid content significantly declined in pear fruits during storage irrespective to the treatments. Due to climacteric nature of pear, increasing trend of TSS was reported during ripening and followed by a decreasing trend as it moves towards senescence. Lower value of total sugars and higher ascorbic acid content were also observed in sodium bicarbonate treated LeConte pear (El-Eryan and El-Metawally, 8). At the end of studies postharvest applications of sodium bicarbonate @ 3% significantly maintained higher level of ascorbic acid (3.56%), as compared to untreated fruits (Table 1). The reduction in ascorbic acid content with storage is confirmed by Ahmed *et al.* (1). During storage untreated fruits exhibited significantly higher mean TSS and total sugars content

Table 1. Effect of sodium bicarbonate treatments on total sugars, TSS, ascorbic acid content and sensory quality of pear fruits during cold storage.

Parameters	Conc (%)	Storage interval (days)				
		0	20	40	60	70
Total sugars (%)	0	6.13±.03[a]	7.98±.22[a]	8.49±.15[a]	8.98±.15[a]	7.16±.14[b]
	1		7.79±.16[b]	8.15±.24[b]	8.50±.17[b]	7.59±.18[b]
	2		7.76±.28[c]	8.05±.18[bc]	8.43±.20[b]	7.65±.16[b]
	3		7.58±.26[c]	7.93±.16 [c]	8.29±.20[c]	7.84±.14[a]
	P		0.001	0.001	0.001	0.001
	LSD(p≤0.05)		0.0703	0.1444	0.1298	0.0763
TSS (%)	0	9.13±0[a]	12.48±.02 [a]	12.67±.08 [a]	13.89±.08 [a]	12.08±.05[d]
	1		12.37±.08[ab]	12.52±.08 [b]	13.78±.08[ab]	12.32±.07 [c]
	2		12.31±.09 [b]	12.44±.10 [bc]	13.69±.07[ab]	12.42±.06[d]
	3		12.27±.11[b]	12.39±.10 [c]	13.65±.05[b]	12.54±.07 [a]
	P		0.0139	0.0018	0.1435	0.001
	LSD (p≤0.05)		0.1213	0.1234	0.2225	0.0765
Ascorbic acid content (%)	0	4.92±.07[a]	3.94±.07[c]	3.75±.07[b]	3.35±.08[c]	2.51±.08[c]
	1		4.07±.11 [b]	3.71±.09[b]	3.42±.07[c]	2.85±.10[b]
	2		4.11±.09[ab]	3.75±.05[b]	3.58±.08[b]	3.47±.07[a]
	3		4.15±.11[a]	3.84±.06[a]	3.71±.08[a]	3.56±.08[a]
	P		0.0001	0.0048	0.0001	0.001
	LSD(p≤0.05)		.0674	.0471	.1161	.1448
Sensory quality (1-9)	0	6.88±.05[a]	8.29±.03[a]	7.64±.08[c]	6.63±.05[c]	5.97±.07[d]
	1		7.78±.05[c]	7.85±.04[bc]	7.32±.07[b]	6.92±.06[c]
	2		7.90±.03 [c]	7.95±.07 [ab]	7.46±.10[ab]	7.10±.10[b]
	3		8.10±.07 [b]	8.19±.08 [a]	7.58±.09[a]	7.28±.05[a]
	P		0.0002	0.0030	0.001	0.001
	LSD (p≤0.05)		0.1727	0.2451	0.1559	0.1499

Mean values followed by same letters within a column are not significantly different at *P ≤ 0.05. n = 4 replications

than sodium bicarbonate treatments. However on 70 days, sodium bicarbonate 3.0% treatment recorded significantly higher TSS and total sugars over the other treatments. At the end of the study, mean TSS and total sugars were significantly lower (0.54 and 2.94%) in sodium bicarbonate treated fruits than control. The decline in TSS and total sugars after 60 days of storage may be due to utilization of carbohydrates in other metabolic activities. Lower TSS and total sugars in sodium bicarbonate treated fruits may be due to reduction of ripening process. Hydrolysis of starch, water loss from fruit surface might have increased TSS and sugars contents of the fruits. Fruit quality is a major factor from consumer's perspective which includes sensory evaluation as well as visual criteria. Patharnakh pear fruit consists of abundance of sclereid cells due to which it has gritty texture. Sensory quality of fruits improved during storage period due to increase in sugar content and reduction in acid concentration. The sensory quality increased from 0 to 40 days of cold storage in fruits treated with different concentrations of sodium bicarbonate. However, in control fruits (8.29) sensory quality increased only up to 20 days of storage which decreased rapidly with progression in storage period (Table 1). Improvement in sensory quality during initial period of storage was due to increase in TSS and reduction in firmness that lead to better taste, however, decline in sensory at the later stages of storage was due to non desirable TSS: acid ratio, firmness and internal browning. Conversely, the rate of reduction in sensory quality of sodium bicarbonate treated fruits was steady with respect to storage time. At the end of study, the sensory scores of sodium bicarbonate treated fruits were above the moderately acceptability level. However, control fruits

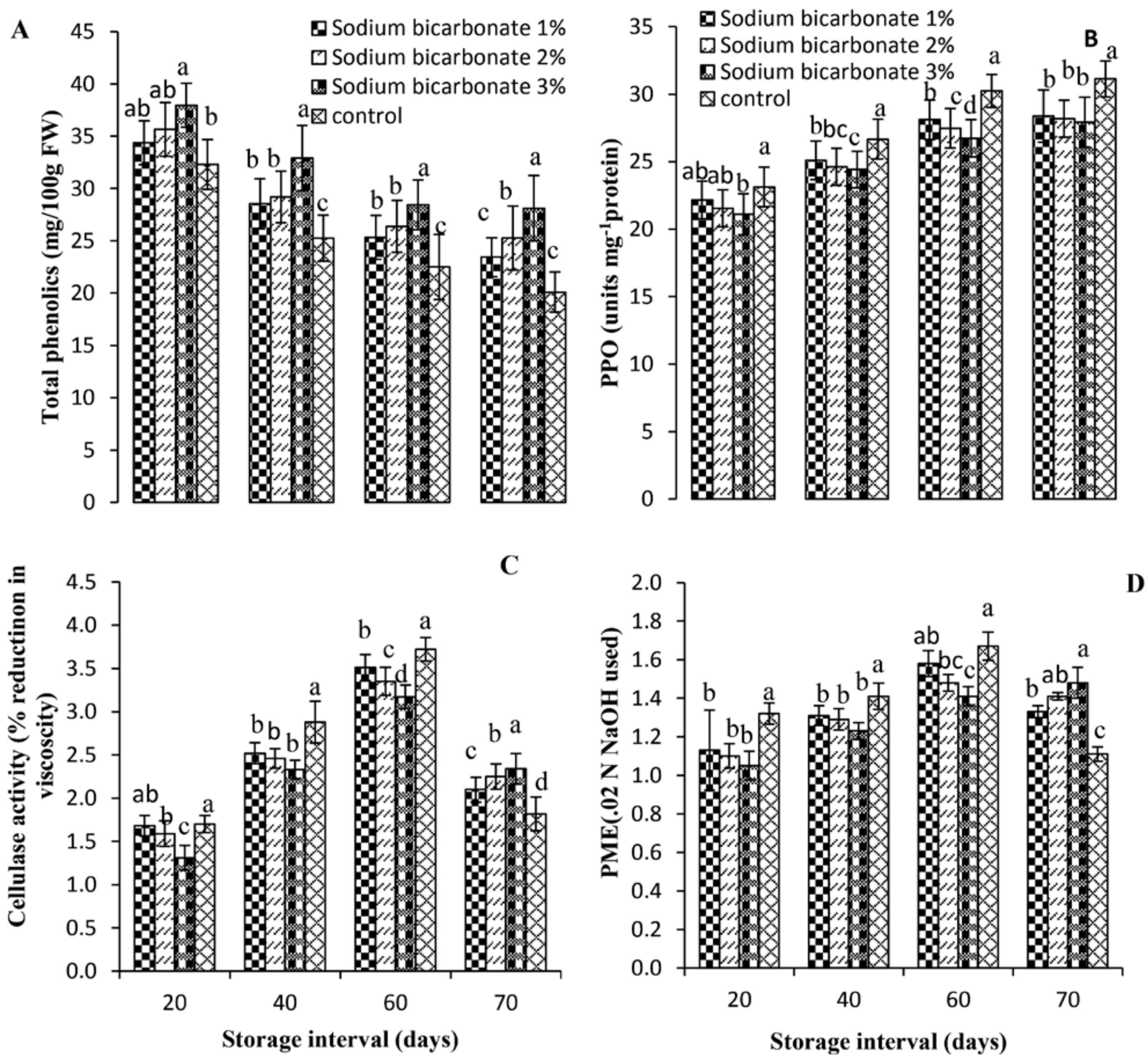


*Values at zero day : weight loss (%) = 0.00, fruit firmness (lbf) = 16.31, spoilage (%) = 0.00, titratable acidity (%) = 0.51

Fig. 1. Variation in weight loss (A), fruit firmness (B), spoilage (C) and titratable acidity (D) of pear fruits during cold storage in relation to different treatments of sodium bicarbonate. Vertical bars represent ± S.E. of means for 4 replicates.

were moderately acceptable on 60th day of storage.

Phenolics content a substrate of PPO was closely linked with tissue browning. Polyphenols are important antioxidants which protects biological systems against oxygen radicals. As storage period progressed, pear fruits exhibited a linear reduction in total phenolics content. However, decrease in total phenolics content was less prominent in sodium bicarbonate treated fruits. At the end of storage, sodium bicarbonate 3% treated fruits exhibited 39.90 % higher total phenolics content as compared to control (Fig. 2A). The accumulation of total phenolics content with ethylene climacteric may be attributed to the role of ethylene in phenolic metabolism (Blankenship and Richard-unrath, 5). Positive effects of sodium bicarbonate on total phenolics content might contribute to lower rate of spoilage percentage of sodium bicarbonate treated pear fruits over the control. PPO enzyme plays an important role in deteriorating the quality of pear fruits and causes enzymatic browning. PPO activity increased with progression of storage period. The mean minimum PPO activity was recorded in 3% sodium bicarbonate treated fruits and mean maximum PPO activity was recorded in control fruits. At the end of storage, control fruits recorded 6.53% higher PPO activity than 2% sodium bicarbonate treated fruits (Fig. 2B). The amount of o-quinones depends mainly on amount of substrates (5-caffeic derivative and catehins) and on polyphenol oxidase activity. PPO



*Values at zero day : Total phenolics (mg/100g FW) = 43.31, PPO (units mg^{-1}protein) = 18.78, cellulase activity(% reduction in viscoscity)= 0.98, PME(0.02 NaOH used) = 0.98

Fig. 2. Variation in activities of TPC (A), PPO (B), Cellulase (C), and PME (D), of pear fruits during cold storage in relation to different treatments of sodium bicarbonate. Vertical bars represent ± S.E. of means for 4 replicates.

comes in a direct contact with substrates. The degradation of phenolics compound in pear could be result of direct oxidation by polyphenol oxidases and oxidation.

The rapid decrease in fruit firmness might be attributed to rapid progression in PME activity, depolymerization of cell wall pectins and also associated with changes in composition of cell wall pectin and turgor pressure. Pectic substances, cellulose, and hemicellulose are the major cell wall polysaccharides, some of which are depolymerized during ripening leading to fruit softening. Pectin degradation in fruits occurred initially by the action of PME. It catalyses the hydrolysis of methyl-ester groups from galacturonosyl residues and plays important role in determining the extent to which demethylated polygalacturonase are accessible to degradation by polygalacturonases (Barnavon *et al.,* 4). As compared to untreated fruits, postharvest treatments of sodium bicarbonate at different concentrations significantly lowered PME activity, the effect being more prominent in 3% sodium bicarbonate. The PME and cellulase activities of pear fruit significantly increased slowly up to 60 days of storage but in contrast to control, sodium bicarbonate (3%) treated fruits showed 15.56% and 14.78% lower PME and cellulase activities, respectively (Fig. 2C, 2D). On 70th day, all the treatments showed decline in enzymes activity and fruits treated with sodium bicarbonate (3.0 %) retained higher activity of PME and cellulase as compared to sodium bicarbonate (1 & 2 %) and control fruits. The higher activity of PME and cellulase in sodium bicarbonate treated fruits might be due to higher level of substrate for enzyme activity which was already decomposed in control fruits. Therefore, the positive affect of sodium bicarbonate on suppression of cell wall degrading enzymes might account for firmer fruits in treated group as compared to untreated group. The activity of PME and cellulase activity exhibited significant interaction between sodium bicarbonate and storage interval. Galactose and arabinose were lost from cell wall during softening of pear fruits. The enzymatic degradation of cell wall materials may be due to modification in fruit cell wall.

It can be concluded from the study that postharvest treatment of sodium bicarbonate @ 3% were found most effective in maintaining physico-chemical and enzymatic activity of pear *cv.* Patharnakh fruits in low temperature storage. It also significantly delayed ripening and inhibition of metabolic activities in fruits which increased postharvest life of fruits upto to 60 days.

REFERENCES

1. Ahmed, D. M., Hafez, O. M. and Fouad, A. A. 2007. Sodium bicarbonate application as an alternative control of postharvest decay of blood orange fruits. *Res. J. Agri. Biol. Sci.* **3**: 753-59.

2. Amerine, M. A., Pangborn, R. M. and Roessler, E. B. 1965. Principles of sensory evaluation of food. *Food Sci. Tech. Monographs*, New York: 338-39.

3. AOAC. 2005. Official method of analysis of AOAC International. (18th ed) AOAC MD, USA.

4. Barnavon, L., Doco, T., Terrier, N., Ageorges, A., Romieu, C. and Pellerina, P. 2001. Involvement of pectin methyl-esterase during the ripening of grape berries: partial cDNA isolation, transcript expression and changes in the degree of methyl-esterification of cell wall pectins. *Phytochem.* **58**: 693-701.

5. Blankenship, S. M. and Richard-unrath, C. 1988. PAL and ethylene content during maturation of red and golden delicious apples. *Phytochem*. **27**: 1001-02.

6. Bradford, M. M. 1976. A rapid and sensitive method for the quantitation of microgram quantities of protein utilizing the principle of protein dye binding. *Anal. Biochem.* **72**: 248-54.

7. De Costa, D.M. and Gunawardhana, H.M.D.M. 2012. Effects of sodium bicarbonate on pathogenicity of *Colletotrichum musae* and potential for controlling postharvest diseases of banana. *Postharvest Biol. Technol*. **68**: 54-63.

8. EL-Eryan, E. E. and EL-Metwally, M. A. 2014. Enhancing storage and shelf life of leconte pear fruits by using sodium bicarbonate and potassium sorbate as a post harvest treatment. *Asian J. Crop Sci.* **6**: 289-304.

9. Mahadevan, A. and Sridhar, R. 1998. *Methods in Physiological Plant Pathology*, (5th ed.), Sivakami Publication, Madras, India.

10. Manteau, S., Abouna, S., Lambert, B. and Legendre, L. 2003. Differential regulation by ambient pH of putative virulence factor secretion by the phytopathogenic fungus *Botrytis cinerea*. FEMS Microb. Ecol. **43**: 359-66.

11. Palou, L., Usall, J., Munoza, J. A., Smilanick, J. L. and Vinas, I. 2002. Hot water, sodium carbonate, and sodium bicarbonate for the control of postharvest green and blue molds of clementine mandarins. *Postharvest Biol. Technol*. **24**: 93-96.

12. Ranganna, S. 2000. *Handbook of analysis and quality control for fruit and vegetable products.* pp. 652 (6th ed.). Tata McGraw-Hill Publishing Co. Ltd, New Delhi.

13. Serradell, M. D. L. A., Rozenfeld, P. A., Martínez, G. A., Civello, P. M., Chaves, A. R. and Anon, M. C. 2000. Polyphenoloxidase activity from strawberry fruit (*Fragaria* × *ananassa*. Duch. *cv*. Selva): characterization and partial purification. *J. Sci. Food Agri.* **80**: 1421-27.

14. Singh, R. P., Chidambara Murthy, K. N. and Jayaprakasha, G. K. 2002. Studies on the antioxidant activity of pomegranate (*Punica granatum*) peel and seed extract using in vitro models. *J. Agri. Food Chem.* **50**: 81-86.

Received : September, 2018; Revised : November, 2018; Accepted : December, 2018