www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.03
TPI 2020; 9(8): 01-04

www.thepharmajournal.com
Received: 04-06-2020
Accepted: 06-07-2020

Palli Venkata Santhosh Kumar
College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India

SL Jagadeesh
College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India

Netravati
College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India

Corresponding Author:
Palli Venkata Santhosh Kumar
College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India

Effect of chlorine and silver synergized zeolite- LDPE composite bags packaging on biochemical properties of banana

Palli Venkata Santhosh Kumar, SL Jagadeesh and Netravati

Abstract
In this study, zeolite-LDPE composite bags with or without infusion of antimicrobial compound (chlorine or silver) were employed as novel packaging materials. The influence of packaging innovation on bio-chemical parameters and shelf life of banana fruits under cold storage condition was investigated. Banana fruits first packed in antimicrobial compound synergized zeolite-LDPE composite bags and then placed in corrugated fiber board (CFB) box showed significantly lower respiration rate and high titratable acidity and more shelf-life than the banana fruits packed in corrugated fiber board (CFB) box alone. Our results suggest that zeolite-LDPE composite bags grafted with antimicrobial compounds could maintained the postharvest quality and increase the shelf-life of banana fruits.

Keywords: Banana, ethylene, LDPE (low density poly ethylene), storage, shelf-life, zeolite

1. Introduction
Banana (*Musa paradisiaca)* is one of the most important commercial tropical fruits. It has been a staple of the human diet since the dawn of recorded history. As banana fruits classified under extremely high ethylene producers, they are highly perishable in nature, ripe quickly, lose moisture rapidly, spoiled faster and achieve senescence rapidly after harvest (Singh and Giri, 2017) [22]. The level of ethylene production in banana fruits increased slowly from the beginning of ripening and reached its peak at 72 hours, which was followed by a decline (Selvaraj and Pal, 1984) [20].
Ethylene is a gaseous plant hormone that plays a major role in the regulation of the metabolism of harvested horticultural crops at very low concentrations (Zhang *et al.*, 2012) [24]. The post-harvest life of both climacteric and non-climacteric fruits can be influenced by ethylene. This hormone affects their quality attributes, the development of physiological disorders and post-harvest diseases (Ernst, 2011) [5]. Effects of ethylene on quality attributes *viz*., external appearance, texture, flavour and nutritive value of fruits have been extensively reported (Saltveit, 1999; Ernst, 2011) [17, 5]. Any closed environment such as truck trailer, shipping container, warehouses, cold rooms and consumer size package results in increase in concentration of ethylene. Therefore, the need to control ethylene activity to extend the post-harvest life of fruits through improvement in packaging, introducing anti-ethylene substances is greater than ever.
Zeolite is a large and diverse class of volcanic aluminosilicate crystalline material which has many useful applications (Khosravi *et al.*, 2015) [12]. The use of zeolite as an adsorbent has started in 1930s followed by Milton, who used zeolite for air purification (Kamarudin, 2006) [10]. Zeolite is a nanoporous crystalline alumina silicate having trihedral and tetrahedral structure. It contains large vacant spaces or cages in its structure that provide space for adsorption of cations or large molecules such as water and ethylene (Khosravi *et al.*, 2015) [12]. It has a rigid, three dimensional crystalline structure consisting of a network of interconnected channels and cages. Water moves freely in and out of these pores, but the zeolite framework remains rigid (Kamarudin, 2006) [10]. Moreover, the incorporation of antimicrobial compounds into zeolite-LDPE composite bags can further improve the physical, mechanical and biological properties of the bag (Lee *et al.*, 2009) [14].
Among inorganic antimicrobial agents, chlorine and silver compounds could highly inhibit microbial growth and show strong biocidal effects on many species of bacteria including *Escherichia coli* (Kim *et al.*, 2007; Lee *et al.*, 2009 and Yang *et al.*, 2009) [13, 14]. The interaction of chlorine and silver ions with microbial cytoplasmic components and nucleic acids can inhibit

the respiratory chain enzymes and interferes with the membrane permeability, limiting the development of bacteria, fungi and yeast (Russel and Hugo, 1994) [16]. In this study, the effect of antimicrobial compounds synergized zeolite-LDPE composite bags packaging on the postharvest quality of banana fruits was evaluated and recorded for the first time.

2. Materials and methods

2.1. Materials and treatments

The present investigation was undertaken in the Department of Post Harvest Technology, University of Horticultural Sciences, Bagalkot, Karnataka, India during the year 2018-19. Banana fruits (cv. Grand Naine) of uniform size and shape, free from any visible damage, scratches and decay were selectively harvested manually from a commercial orchard at proper maturity stage. The maturity stage was judged as right stage based on skin colour of the fruits which changed from dark green to light green and ridges on the surface of fingers changed from angular to round. The fruits were brought to the laboratory in plastic crates. Soon, the plastic crates containing fruits were placed in the cold room for pre-cooling by room cooling method at 13°C for 12 hours. Then fruits were packed in zeolite-LDPE composite bags with or without outer CFB box *viz.*, Silver-zeolite-LDPE composite bag (T_1), Zeolite-LDPE composite bag (T_2), Chlorine-zeolite-LDPE composite bag (T_3), Silver-zeolite-LDPE composite bag + CFB box (T_4), Zeolite-LDPE composite bag + CFB box (T_5), Chlorine-zeolite-LDPE composite bag + CFB box (T_6), Commercially used CFB (T_7) and Control (without any package) (T_8) @ 6 fruits/treatment (per bag) and stored under refrigerated (13±1°C, 85-90% RH) conditions. A thermostat of the walk-in cold room maintained the set temperature. Relative humidity in the storage chamber was maintained by with the help of a humidifier.

2.2. Packing of fruits in zeolite-LDPE composite bags

Zeolite-LDPE composite bags with variations (with or without chlorine or silver) were procured from J. J. Overseas private Limited, Mumbai, India. The banana fruits were packed @ 6 fruits per bag. Each pack of fruits was kept undisturbed under the storage condition prescribed above until the scheduled date of observation. Thus, there were so many numbers of packs under each treatment as the number of times the fruits were observed at scheduled interval. Banana fruits were observed for 8 times for each treatment. There were 8 packs each containing 6 fruits for each treatment. All the fruit-packs removed from storage condition on scheduled day of observation were used to record different observations. Thus, each pack in the storage condition passed through the storage time undisturbed until it was finally taken out to observe for different parameters.

2.3. Respiration rate (ml CO_2 $kg^{-1}h^{-1}$)

The rate of respiration was measured by static head space method using gas analyzer (Make: PBI, DANSENSOR, and CHECKMATE 2) and expressed as ml $CO_2kg^{-1}h^{-1}$. To carry out this method, four banana fruits were trapped in 3000 ml airtight containers having twist-top lid fitted with a silicone rubber septum at the center of lid. The containers were kept for an hour for accumulation of respiratory gases at the head space. After specified time, the head space gas was sucked to the sensor of the analyzer through the hypodermic hollow needle and the displayed value of evolution of CO_2 concentration (%) was recorded. Further, the rate of respiration was calculated on the basis of amount of CO_2 evolved from the fruit per unit weight per unit time using the following formula.

2.4. Titratable acidity (%)

Five grams of homogenized pulp was made up to 100 ml and filtered through muslin cloth. Then, 10 ml of the filtrate was taken for titration against 0.1 N NaOH solution using phenolphthalein as an indicator. The appearance of light pink colour was considered as end point. The acidity was calculated and expressed as per cent malic acid.

$$\text{Acidity (\%)} = \frac{\text{Titre value} \times \text{N of NaOH} \times \text{Vol. made up} \times \text{Eq. weight of acid}}{\text{Vol. of aliquot} \times \text{Vol. of sample taken} \times 1000} \times 100$$

2.5 Shelf life (days)

The number of shelf life days was decided based on physiological loss in weight (PLW). A PLW of 10% was considered as the upper limit for determination of shelf life (Jaya, 2010).

2.6. Experimental design and data analysis

The first experiment was carried out with 3 replicate fruits and the experiment was repeated 3 times and pooled data was subjected to statistical analysis. Fruits were arranged in Complete Randomised Design. The second experiment was carried out for 3 replicate fruits and repeated 3 times. Randomly selected 8 fruits were taken to analyse physiological loss in weight, respiration rate, colour value of peel ($L*$, $a*$ and $b*$), Total Soluble Solids (TSS), titratable acidity, firmness, disease score and shelf life and all the experiments were repeated 3 times. The data of experiment was analyzed as applicable to completely randomized design (CRD). Statistical analyses of experiments were performed using Web Agri Stat Package (WASP) Version 2 (Jangan and Thali, 2010). The level of significance used in 'F' and 't' was p=0.01 and also p=0.05 for some parameters. Critical difference values were calculated whenever F-test was found significant.

3. Results

3.1. Respiration rate (ml CO_2 $kg^{-1}h^{-1}$)

Fresh banana fruits used in the study had respiration rate of 96.7 ml CO_2 /Kg/hr. With storage, mean of respiration rate increased in all the treatments up to 15 days and a decrease at 18 and 21 DAS (Table 2). The data revealed significant differences with respect to respiration rate of banana during 18 DAS. The rate was found to be minimum in the treatment T_6 (Chlorine-zeolite-LDPE composite bag + CFB box) throughout the storage (3 DAS-98.4; 6 DAS-104.5; 9 DAS-118.5; 12 DAS-126.8; 15 DAS-183.8; 18 DAS-180.1 and 21 DAS-156.1 ml CO_2 /Kg/hr) in comparison to all other treatments.

3.2. Titratable acidity (%)

Titratable acidity (%) was found to increase from the initial value (0.16%) up to 3 DAS and later declined in all the storage treatments of sapota (Table 8). At all the days of observation, maximum acidity was associated with T_6 (Chlorine-zeolite-LDPE composite bag + CFB box) (3 DAS-0.63%; 6 DAS-0.60%; 9 DAS-0.57%; 12 DAS-0.53%; 15 DAS-0.49%; 18 DAS-0.47% and 21 DAS-0.42%).The treatment T_8 (Control) showed significantly minimum titratable acidity (3 DAS-0.29%; 6 DAS-0.26%; 9 DAS-0.22%; 12 DAS-0.19%; 15 DAS-0.18%; 18 DAS-0.16% and

21 DAS-0.15%) closely followed by T_7 (Commercially used CFB) and T_2 (Chlorine-zeolite-LDPE composite bag) throughout the study duration.

3.3. Shelf life (days)
Banana fruits recorded significantly maximum shelf life (days) in T_6 (Chlorine-zeolite-LDPE composite bag + CFB box) (21.00 days) (Table 9) which was statistically on par with T_4 (19.66 days) and minimum shelf life (days) was recorded in T_8 (Control) (14.66 days). However, the treatment T_8 was on par with T_7 (only CFB box) (15.66 days).

4. Discussion
4.1. Respiration rate (ml CO_2 $kg^{-1}h^{-1}$)
In the present study, hurdle to respiration process was created by low temperature as well as zeolite composed package. Porous zeolite is effective in adsorbing gases such as oxygen, carbon dioxide and ethylene and water vapour, and thereby reducing respiration (Khosravi *et al.*, 2015) [12]. The rate was found to be minimum in the treatment T_6 (Chlorine-zeolite-LDPE composite bag + CFB box) (Table.1) throughout the storage This is possibly due to biocidal effect of chlorine (Kim *et al.*, 2007; Lee *et al.*, 2009 and Yang *et al.*, 2009) [13, 14] leading to delay in fruit senescence. Reduced respiration of fruits in zeolite-LDPE variants (with or without chlorine or silver) in CFB boxes (T_4, T_5, T_6) than those without CFB (T_1, T_2, T_3) could be due to beneficial synergistic effect of combined packages. Banana fruits kept open condition (T_8) had significantly higher respiration rate followed closely by T_7 (Commercially used CFB) throughout the storage period. This defends the beneficial effect of zeolite-LDPE bags.

4.2. Titratable acidity (%)
The most important feature of zeolite is effective adsorption of gases such as oxygen, carbon dioxide and ethylene and water vapour leading to reduced respiration and metabolism of fruits (Khosravi *et al.*, 2015) [12]. Reduction in metabolism could reduce the use of organic acids as substrates in respiration (Islam *et al.*, 1996), thus resulting higher acidity in fruits. The T_6 (Chlorine-zeolite-LDPE composite bag + CFB box) recorded higher acidity than the fruits without any package (T_8) (Table.2). Further, higher titratable acidity in antimicrobial compounds synergized zeolite-LDPE variants in CFB boxes (T_4, T_5, T_6) than those without CFB (T_1, T_2, T_3) could be due to beneficial synergistic effect of combined packages. Lower titratable acidity observed in fruits kept in CFB alone (T_7) strongly justifies the effect of zeolite-LDPE bags with or without antimicrobial compounds. Bhutia *et al*. (2011) revealed that sapota fruits packed along with ethylene absorbers showed marked retardation of ripening and also maintenance of higher acidity in comparison to control fruits.

4.3. Shelf life (days)
Bananas recorded a shelf-life of 18.00 days in the treatment T_6 (Chlorine-zeolite-LDPE composite bag + CFB). This treatment resulted in additional shelf-life of 6 and 5 days in comparison to T_8 (12 days) and T_7 (13 days) respectively (Table.2). The additional shelf life in T_6 is due to effectiveness of porous zeolite in adsorbing ethylene (Khosravi *et al.*, 2015) [12]. Sarkar *et al.* (2017) [19] reported the shelf life extension in banana fruits up to 20 days by packing in LDPE along with 5gm KMnO4 sachet. Extension of shelf life in cut apples packed in punnet boxes with a pouch of zeolite (1 g) up to 10 days was reported (Khosravi *et al.*, 2015) [12]. However, T_6 differed significantly over other variants of zeolite-LDPE composite bags (T_1 – T_5) used in this study. Unique and combined effectiveness of chlorine-zeolite-LDPE and CFB box (T_6) in minimizing the action of ethylene and combating pathogenic organisms are the reasons for additional shelf-life benefit.

5. Conclusions
Our results have shown that antimicrobial compounds synergized zeolite-LDPE composite bags packaging had a positive effect on the postharvest quality of banana fruits. The preservation effect of antimicrobial compounds synergized zeolite-LDPE composite bags could be attributed to its intrinsic ethylene adsorbing property as well as antimicrobial property. Thus banana fruits packaged with antimicrobial compounds synergized zeolite-LDPE composite bags showed lower respiration rate and higher titratable acidity and more shelf-life. These indicated that antimicrobial compounds synergized zeolite-LDPE composite bags could be explored as a novel active packaging material for the postharvest storage of banana fruits.

Table 1: Effect of zeolite-LDPE composite bags on respiration rate (ml 0f CO_2 /Kg/hr) of banana fruits under refrigerated condition (13°C)

Treatments	Respiration rate (ml 0f CO_2 /Kg/hr)							
	3 DAS	6 DAS	9 DAS	12 DAS	15 DAS	18 DAS	21 DAS	Mean
Initial	96.7							
T_1	101.1^{bc}	109.7^{bcd}	132.2^{c}	151.6^{abc}	196.7^{bc}	187.0^{cd}	168.5	149.54
T_2	102.5^{b}	111.1^{abc}	135.3^{b}	158.8^{ab}	201.9^{ab}	189.5^{bc}	170.9	152.85
T_3	100.8^{bc}	108.2^{cde}	128.6^{c}	147.9^{bc}	194.4^{bc}	186.6^{cd}	164.4	147.27
T_4	99.4^{cd}	106.3^{de}	121.8^{e}	135.4^{cd}	188.6^{cd}	183.4^{d}	158.3	141.88
T_5	100.7^{bc}	107.9^{bcde}	125.1^{d}	142.3^{bcd}	192.6^{bcd}	184.4^{d}	161.7	144.95
T_6	98.4^{d}	104.5^{e}	118.5^{f}	126.8^{d}	183.8^{d}	180.1^{e}	156.1	138.31
T_7	103.9^{a}	112.8^{ab}	138.4^{ab}	161.6^{ab}	208.0^{a}	190.6^{b}	172.6	155.41
T_8	105.2^{a}	114.6^{a}	141.0^{a}	167.7^{a}	212.3^{a}	194.8^{a}	189.8	160.77
Mean	101.50	109.38	130.11	149.01	197.28	187.05	167.78	
S.Em±	0.57	1.50	1.04	6.50	2.19	1.39	14.00	
CD@1%	2.38	6.21	4.32	26.87	14.48	5.78	NS	

T_1- Silver-zeolite-LDPE composite bag
T_2 - Zeolite-LDPE composite bag
T_3 - Chlorine-zeolite-LDPE composite bag
T_4 - Silver-zeolite-LDPE composite bag + CFB
T_5 - Zeolite-LDPE composite bag + CFB
T_6 - Chlorine-zeolite-LDPE composite bag + CFB
T_7 - Only CFB
T_8 – Control

Table 2: Effect of zeolite-LDPE composite bags on titratable acidity (%) and shelf life (days) of banana fruits under refrigerated condition (13°C)

Treatments	Titratable acidity (%)								Shelf life (days)
	3 DAS		9 DAS	12 DAS	15 DAS	18 DAS	21 DAS	Mean	
Initial	0.16								
T_1	0.43^{bcd}	14.33^{b}	0.37^{cd}	0.34^{bcd}	0.31^{bcd}	0.30^{bc}	0.28^{bc}	0.34	14.33^{b}
T_2	0.39^{cd}	14.00^{bc}	0.34^{cde}	0.32^{cd}	0.30^{cde}	0.29^{bc}	0.26^{cd}	0.32	14.00^{bc}
T_3	0.48^{abc}	14.66^{b}	0.41^{bc}	0.38^{bc}	0.35^{bc}	0.33^{b}	0.30^{bc}	0.38	14.66^{b}
T_4	0.56^{ab}	15.00^{b}	0.50^{ab}	0.46^{ab}	0.43^{ab}	0.40^{ab}	0.38^{ab}	0.46	15.00^{b}
T_5	0.51^{abc}	14.66^{b}	0.46^{abc}	0.43^{abc}	0.41^{abc}	0.39^{ab}	0.36^{abc}	0.43	14.66^{b}
T_6	0.63^{a}	18.00^{a}	0.57^{a}	0.53^{a}	0.49^{a}	0.47^{a}	0.42^{a}	0.53	18.00^{a}
T_7	0.32^{d}	13.00^{cd}	0.27^{de}	0.24^{de}	0.22^{de}	0.20^{cd}	0.18^{de}	0.24	13.00^{cd}
T_8	0.29^{d}	12.00^{d}	0.22^{e}	0.19^{e}	0.18^{e}	0.16^{d}	0.15^{e}	0.20	12.00^{d}
Mean	0.45	14.45	0.39	0.36	0.33	0.31	0.29		14.45
S.Em±	0.03	0.34	0.03	0.04	0.05	0.02	0.04		0.34
CD@1%	0.21	1.46	0.19	0.17	0.16	0.15	0.14		1.46

T_1- Silver-zeolite-LDPE composite bag
T_2 - Zeolite-LDPE composite bag
T_3 - Chlorine-zeolite-LDPE composite bag
T_4 - Silver-zeolite-LDPE composite bag + CFB
T_5 - Zeolite-LDPE composite bag + CFB
T_6 - Chlorine-zeolite-LDPE composite bag + CFB
T_7 - Only CFB
T_8 - Control

References

1. Abhay M, Singh SP, Karuna K, Wasim S. Biochemical changes in tissue cultured banana cv. Dwarf Cavendish during storage in response to different packaging. Res. J. Chem. Environ. 2015; 19(8):43-50.
2. Amir-Shapira D, Goldschmidt EE, Altman A. Chlorophyll catabolism m senescing plant tissues: *In viva* breakdown-intermediates suggest different degradative pathways for Citrus fruit and parsley leaves. Proc. Natl. Acad. Sci. USA. 1987; 84:1901.
3. Bhutia W, Pal RK, Sen S, Jha SK. Response of different maturity stages of sapota (*Manilkara achras* mill.) cv. Kallipatti to in package ethylene absorbent. J. Food sci. Technol. 2011; 48(6):763-768.
4. Born RE, Salomao LCC, Siqueira DL, Cecon PR, Rocha A. *Potassium permanganate* effects in postharvest conservation of the papaya cultivar Sunrise Golden. Pesq Agrop Bras. 2004; 44(7):669-675.
5. Ernst AA. Interaction of storage, ethylene and ethylene inhibitors on post harvest quality of Maluma. Proceedings VII World Avocado Congress 2011 (Actas VII Congreso Mundial del Aguacate 2011), 2011.
6. Hailu M, Seyoum Workneh T, Bele D. Effect of packaging materials on shelf life and quality of banana cultivars (Musa spp.). J. Food Sci. Technol. 2012; 51(11):2947-2963.
7. Islam SM, Matsui T, Yoshida Y. Effect of carbon dioxide enrichment on physico-chemical and enzymatic changes in tomato fruits at various stages of maturity. Sci. Hort. 1996; 65:137-149.
8. Jangam AK, Thali P. ICAR Research Complex, Goa, Old Goa, Goa (India), 2010, 402-403.
9. Jaya PM. Effect of polyethylene film packaging on quality and shelf-life of sapota fruits. A Thesis submitted to Punjab agriculture university, India, 2010.
10. Kamarudin KS. Structural and gas adsorbtion characteristics of zeolite adsorbents. University Technology Malaysia, 2006, 12-20.
11. Kays SJ. Postharvest physiology of perishable plant products. CBS Publications, 1998, 151-159.
12. Khosravi F, Khosravi M, Pourseyedi E. Effect of nano zeolite and potassium permanganate on Shelf Life and Quality of Cut Apple. Inter. J. Lifesci. 2015; 9(2):55-60.
13. Kim JS, Kulk E, Yu KN, Kim JH, Park SJ, Lee HJ *et al*., Antimicrobial effect of silver nanoparticles. J. Nanomedicine and Nanotechnology. 2007; 3:95-101.
14. Lee S, Lee J, Kim K, Sim SJ, Gu MB, Yi J Eco-toxicity of commercial silver nanopowers to bacterial and yeast strains. Biotechnol. Boprocess Engin. 2009; 14:4158-4163.
15. Pongprasert QE, Srilaong DU. Comparitive morpho anatomy and physiology of the banana and mango. Postharvest biochemistry of plant food materials in the tropics. Japan Sci. Societies Press, Tokyo, 2014, 135-147.
16. Russel AD, Hugo WB Antimicrobial activity and action of silver. Progress in Medical Chemistry. 1994; 31:351-370.
17. Saltveit ME. Effect of ethylene on quality of fresh fruits and vegetables. Post harvest Biol. Technol. 1999; 15:279-292.
18. Salunkhe DK, Desai BB. Postharvest biology of fruits. 1 CRC Press, Boca Raton, Florida, 1984,
19. Sarkar E, Sharma RR, Singh D. Effect of different packaging materials on shelf-life and quality of apple during storage. Int. J. Hort. 2017; 67(1):94-101.
20. Selvaraj Y, Pal DK. Changes in chemical composition and enzyme activity of the sapodilla cultivars during development and ripening. J. Horti. Sci. 1984; 59:275-281.
21. Seymour GB. Banana. In: Seymour GB, Taylor JE, Tucker GA (eds) Biochemistry of fruit ripening. Chapman and Hall, London, 1987, 83-106.
22. Singh R, Giri SR, Wang P. Shelf life study of sapota under active packaging: An experiment with potassium permanganate salt as ethylene absorbent. Int. Congress Agri. Fodd Eng. Sci. 2017, 23:32.
23. Yang W, Shen C, Ji Q, An H, Wang J, Liu Q, Zhang Z. Food storage material silver nanoparticles interfere with DNA replication fidelity and blind with DNA. Nanotechnology. 1994; 20:85-102.
24. Zhang Z, Tian SH, Zhu Z, Xu Y, Qin G. Effects of 1-methylcyclopropene(1-MCP) on ripening and resistance of jujube (*Zizyphus jujuba* cv. Huping) fruit against postharvest disease. Food Sci. Techno. 2012; 45:13-19.
25. Zomorodi SH. Effect of packaging and potassium permanganate on quality and shelf life of apples in cold storage. J. Agric. Engi. Res. 2005; 24(6):143-156.