Current Journal of Applied Science and Technology

22(2): 1-8, 2017; Article no.CJAST.33111
Previously known as British Journal of Applied Science & Technology
ISSN: 2231-0843, NLM ID: 101664541

Implication of Nanocomposite Edible Coating for Shelf Life Extension of Indian Olive (*Elaeocarpus floribundus* Blume)

Arkendu Ghosh[1*], Koyel Dey[1], Arghya Mani[2], A. N. Dey[3] and F. K. Bauri[1]

[1]Department of Fruits and Orchard Management, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal-741252, India.
[2]Department of Pomology and Post Harvest Technology, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar-736165, India.
[3]Department of Forestry, Uttar Banga Krishi Viswavidyalaya, Pundibari, Cooch Behar-736165, India.

Authors' contributions

This work was carried out in collaboration between all authors. Authors AG and KD designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors AM and AND managed the analyses of the study. Author FKB managed the literature searches. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/CJAST/2017/33111
Editor(s):
(1) Teresa De Pilli, University of Foggia, Department of Science of Agriculture of Food of Environment (SAFE), Via Napoli, 25; 71100 Foggia, Italy.
(2) Ya-mei Gao, College of life science and technology, Heilongjiang Bayi Agariculture University, Daqing, Heilongjiang, China.
(3) Harry E. Ruda, University of Toronto, Director, Centre for Advanced Nanotechnology, University of Toronto, Canada.
Reviewers:
(1) Vintila Iuliana, Dunarea de Jos University Galaţi, Romania.
(2) Tugba Oksuz, Istanbul Technical University, Turkey.
(3) Maria Elisa Caetano-Silva, University of Campinas, Brazil.
Complete Peer review History: http://www.sciencedomain.org/review-history/19904

Original Research Article

Received 30th March 2017
Accepted 23rd May 2017
Published 6th July 2017

ABSTRACT

Aims: To study the efficacy of nanocomposite edible coating on shelf life extension of Indian olive.
Study Design: Completely randomized design.
Methodology: We examined the effects of different concentration of guar gum as an edible coating on shelf life of Indian olives. There are five treatments and four replication viz. T_1- Guar gum 0.5%, T_2- Guar gum 1%, T_3- Guar gum 1.5%, T_4- Guar gum 2%, T_5- Control. Different observations recorded are: loss in weight (LW), decay percentage, fruit length and breadth, Total soluble solids (TSS), Acidity, Ascorbic acid, Total sugar and reducing sugar.

**Corresponding author: E-mail: arkofruits@gmail.com;*

Results: Investigation revealed that the highest results were obtained in T_3 (guar gum 1.5%) in term of lowest LW% (16.85%) and decay percent (34.68%) along with preserving the chemical composition of the fruits whereas T_5 gave lowest performance.
Conclusion: Among the different treatments, T_3 (Guar gum 1.5%) appears adequate in significantly delay in all physico-chemical parameters during storage as compared to fruits under control.

Keywords: Jalpai; guar gum; fruit quality; antioxidant capacity; storage life.

1. INTRODUCTION

Indian olive (*Elaeocarpus floribundus* Blume) is a species belongs to family Elaeocarpaceae that commonly occurs in the lowland, hills and mountains in Bangladesh, India, Burma, Thailand, Vietnam, Malaysia and Indonesia up to 1500 m elevation. Leaves are ovate-elliptic, thinly leathery, varying from 6.5 x 3 cm to 19 x 8.5 cm, with a long pointed tip and toothed margin [1]. In West Bengal conditions flowers appear in the summer months (April to May) and fruits are harvested during August to October [2]. Fruits are greenish, single seeded, drupe and the edible portion of the fruit is the mesocarp around the seeds. The fruits are mainly marketed locally and a very small quantity in other parts of West Bengal. However, it has a short postharvest life due to several factors such as high rate of respiration, weight loss and enhanced ripening, which result in the early deterioration of fruit quality. Cultivation of Indian olive (locally known as Jalpai) is popular in present days in homestead garden for production of several value added products likes chutneys, pickles etc. But due to the surplus of fruits in the local markets during peak season (August to October), a substantial quantity goes to waste, resulting in heavy postharvest losses. Several techniques such as refrigeration, modified atmosphere storage, chemical preservatives and packaging are being used to minimize deleterious effects. Controlled atmosphere and hypobaric storage can lengthen the storage life of fruits but these processes are capital intensive and costly to run [3]. Among several techniques, uses of nanomaterials have potentiality to revolutionize the agricultural and horticultural food industry. Thus it can potentially enhance yields, nutritional values, ability of plants to absorb nutrients or pesticides and improved post-harvest life [4]. The using of edible coating of nanoparticles (Chitosan, Gum tragacanth, Guar gum etc.) has received more attention in recent years, due to the growing interest for low purchasing cost, reducing environmental pollution caused by plastics, the need to extend the shelf life of foods, and the increasing demand for healthier and ecological foods [5]. Among different types of edible coating, Chitosan, Gum tragacanth and Guar gum are known to extend the shelf life of guava [6], star fruit [7] and tomato [8]. However, very little information in this regard is available for this area with Indian olive. In view of the above facts this experiment was carried out to determine whether guar gum as a novel edible coating for increasing the shelf life as well as maintaining the physico-chemical properties of the fruit.

2. MATERIALS AND METHODS

2.1 Sample Collection

Fully matured, uniform size Indian olive fruits were collected from a homestead garden at Nadia, West Bengal in August, 2016 and immediately brought to the laboratory of the Department of Fruits and Orchard Management, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal for ambient storage after necessary treatments. The fruits after washing in running tap water were dried in the shade for few minutes.

2.2 Treatment Details and Formulation

A set of 120 fruits with 30 fruits per replication were taken each of the following treatments having four replications. The fruits were subjected to edible coating of following treatments: T_1- Guar gum 0.5%, T_2- Guar gum 1%, T_3- Guar gum 1.5%, T_4- Guar gum 2%, T_5- Control. Guar gum (purchased from HIMEDIA, Mumbai, India) coating solution was prepared on the percentage of weight basis with distilled water. 0.5 g, 1 g, 1.5 g and 2 g guar gum powder was mixed with 100 mL of water for the preparation of 0.5%, 1%, 1.5% and 2% solutions, respectively. Solutions were heated in oven, cooled in air followed by Wijewardane et al. [9].

2.3 Observations Recorded

Fruit samples were analysed for physico-chemical properties up to 12 days of storage at an interval of 3 days after coating treatments.

2.3.1 Loss in weight

The loss in weight was calculated based on initial weight and weight at subsequent intervals. The decay percentage of fruits were calculated as the number of decayed fruit divided by initial number of all fruit multiplied by hundred [10].

2.3.2 Length and breadth

The length and breadth (millimeter scale) of Indian olive fruits were measured as an index for shrinkage and it was measured by digital vernier callipers at zero time of storage (beginning) and 3 days interval during the storage period.

2.3.3 Fruit colour

The fruit colour was recorded with the help of Royal Horticulture Society Mini Colour Chart (Fifth edition, 2007).

2.3.4 Total Soluble Solids

Total Soluble Solids (TSS) content of the fruit was recorded by hand Refractometer following the principle of total refraction which was calibrated at 0° Brix at 20℃ along with a temperature correction correlation chart. A few drops of fruit juice from each sample were installed on the plate to record the Refractometer reading, in ^{o}Brix at different temperature [11].

2.3.5 Titrable acidity

The titrable acidity of the fruit juice was estimated by titrating against standard alkali solution (0.1 N NaOH) using the phenolphthalein indicator and is expressed in percentage [12].

2.3.6 Ascorbic acid

Ascorbic acid content was estimated based on the oxidation of ascorbic acid to diketogluconic acid followed by coupling with 2,4 DNPH. It was measured colorimetrically by UV/Vis spectrometer (Perkin Elmer, Lambda 25) and expressed as mg per 100 g fruit pulp [12].

2.3.7 Total sugar and reducing sugar

Total sugar and reducing sugar were estimated by the method described by Mazumdar and Majumder [11].

2.4 Statistical Analysis

This experiment had a completely randomized design with five (5) treatments and four (4) replications. The data were analysed following Analysis of Variance (ANOVA) technique and mean differences were adjusted by the multiple comparison test [13] using the statistical computer based programme MSTAT-C v.2.1. [14]. The significance of different source of variance was tested by error mean square of 'F' test at probability level 0.05. Fisher and Yate's tables were consulted for the determination of critical difference at 5% level of significance.

3. RESULTS AND DISCUSSION

3.1 Loss in Weight (LW %)

Loss in weight increased in all the treatments as the storage period progressed (Table 1). On 3 days after treatment, the LW % was found minimum (8.93%) in fruits treated with T_3 (guar gum 1.5%) followed by T_4 (8.99%), whereas, it was maximum (12.73%) in the fruits under control (T_5). On 12 days after treatment, it (LW%) was found minimum (16.85%) in T_3 followed by T_4 (18.36%) where as it was maximum (23.66%) in control (T_5). Loss in weight for all treated fruits were statistically significant ($p<0.05$) during the storage periods. The reduction in weight loss was probably due to the effects of these coatings as a semi permeable barrier against oxygen, carbon dioxide, moisture and solute movement, thereby reducing respiration, water loss and oxidation reaction rates [15]. Oluwaseun et al. [16] observed that coated cucumber showed a significant delay in weight loss compared to uncoated ones.

3.2 Decay Percent

Observation during storage of Indian olive fruits revealed that incidence of decay percent is increased in all the treatments as the storage period progressed. However, fruits treated with 1.5% guar gum coating (T_3) showed minimum decay (34.68%) after 12 days of storage than uncoated fruits (T_5) which showed maximum decay (68.79%). The decrease in decay percentage was probably due to the effect of the coating which delaying the senescence and makes the commodity less vulnerable to pathogenic infection [17]. Similar results also reported by Rehman et al. [18] in strawberries and Ali et al. [19] in tomatoes due to microbial inhibition characteristics of edible coatings.

3.3 Fruit Length and Breadth

Observation during storage of Indian olive fruits revealed that the shrinkage percentage (Table 3) was increased in all the treatments as the storage period progressed. T_3 (Guar gum 1.5%) showed a lower percentage of shrinkage compared to other treatments and control fruits. The shrinkage percentage of T_3 was 3.12% (from 30.65 cm to 29.70 cm) for fruit length and 5.35% (from 20.77 cm. to 19.66 cm.) for fruit breadth. It might be due to the anti-senescent action of coatings which had an inhibitory effect on ethylene biosynthesis and retard the activity of enzymes responsible for ripening, cell degradation was prevented which in turn facilitated reduced moisture loss and lesser respiratory gas exchange, hence delay in senescence and lower the shrinkage percentage [20].

3.4 Fruit Colour

Fruit colour of Indian olive fruits changed from different shades of green to yellowish-green during storage (Table 4). At the end of the storage, fruits became yellow and reduced their marketability. However fruits treated with guar gum 1.50% (T_3) maintained the green colour (GG143C) up to 9th day of storage, compare to other treatments and maintained consumer acceptability. Guar gum coating (1.5%) was more effective in delaying the ripening of jalpai fruits compared to control samples might be due to an increase in CO_2 and decrease in O_2 levels. Ghosh et al. [8] observed that tomato coated with guar gum helped to maintain the colour during storage. Generally the yellowness increased with storage time due to ripening of fruits [21].

3.5 Total Soluble Solids (TSS)

The Total soluble solids content of the fruits were significantly affected by all the treatments. However it is decreased with the storage period progressed (Table 5). On 3 days after treatment, the TSS content was found highest (9.97 ^{o}brix) in T_3 followed by T_2 (9.46 ^{o}brix), whereas, it was lowest (8.84 ^{o}brix) in control (T_5). However, on 12 days after treatment, the TSS content was also found maximum (7.65 ^{o} brix) in T_3 followed by T_4 (7.23 ^{o}brix) and was minimum (6.14 ^{o}brix) in T_5. These results are similar with Smith and Stow, [22] who concluded that coatings or films significantly affected TSS. Decreased respiration rates slow down the synthesis and use of metabolites resulting in lower TSS [23]. The loss of soluble solids during the storage period is as natural as sugars which are the primary constituent of the soluble solids content of a product, consumed by respiration and used for the metabolic activities of the fruits [24].

Table 1. Effect of nano coating (guar gum) on loss in weight (%) of Indian olive

Treatments	Loss in weight			
	3 DAS	6 DAS	9 DAS	12 DAS
T_1	9.06 (17.51)	12.16(20.42)	15.25(22.99)	18.77(20.42)
T_2	9.05(17.51)	12.05(20.32)	15.10(22.87)	18.54(20.32)
T_3	8.93(17.39)	10.84(19.24)	13.73(21.74)	16.85(19.24)
T_4	8.99(17.44)	11.53(19.84)	14.53(22.40)	18.36(19.84)
T_5	12.73(20.92)	15.66(23.32)	19.47(26.19)	23.66(23.32)
SEm (±)	0.03	0.02	0.02	0.02
CD(0.05)	0.08	0.07	0.07	0.06

DAS= Days After Storage; T_1- Guar gum 0.5%, T_2- Guar gum 1%, T_3- Guar gum 1.5%, T_4- Guar gum 2%, T_5- Control

Table 2. Effect of nano coating (guar gum) on decay percent of Indian olive

Treatments	Decay			
	3 DAS	6 DAS	9 DAS	12 DAS
T_1	8.03(16.49)	18.63(25.57)	29.35(32.80)	58.05(49.63)
T_2	6.82(15.15)	15.45(23.15)	32.84(34.97)	45.54(42.45)
T_3	3.53(10.82)	7.55(15.95)	15.14(22.93)	34.68(36.09)
T_4	7.65(16.06)	18.45(25.44)	38.66(38.46)	60.15(50.86)
T_5	12.48(20.70)	18.85(20.74)	42.15(40.50)	68.79(56.06)
SEm (±)	0.03	2.23	0.02	0.02
CD(0.05)	0.09	6.72	0.05	0.05

DAS= Days After Storage; T_1- Guar gum 0.5%, T_2- Guar gum 1%, T_3- Guar gum 1.5%, T_4- Guar gum 2%, T_5- Control

Table 3. Effect of nano coating (guar gum) on length and breadth (cm) of Indian olive

Treatments	Days after treatments									
	3		6		9		12		Shrinkage	
	Length	Breadth	Length	Breadth	Length	Breadth	Length	Breadth	Length	Breadth
T_1	30.44	20.35	30.07	19.93	29.56	19.34	28.95	18.85	4.91	7.40
T_2	31.15	20.19	30.85	19.74	30.14	19.23	29.15	18.50	6.41	8.36
T_3	30.65	20.77	30.43	20.52	30.16	20.24	29.70	19.66	3.12	5.35
T_4	30.36	20.25	30.05	19.86	29.44	19.22	28.35	18.41	6.65	9.09
T_5	29.63	20.45	28.13	19.35	27.22	18.26	25.85	16.54	12.74	19.16
SEm (±)	0.02	0.02	0.02	0.02	0.02	0.02	0.02	0.02	-	-
CD(0.05)	0.05	0.05	0.05	0.05	0.05	0.07	0.05	0.05	-	-

T_1- Guar gum 0.5%, T_2- Guar gum 1%, T_3- Guar gum 1.5%, T_4- Guar gum 2%, T_5- Control

Table 4. Effect of nano coating (guar gum) on fruit colour of Indian olive

Treatments	Days after treatments			
	3	6	9	12
T_1	YGG146B	YGG146B	YGG146C	YGG146C
T_2	YGG144B	YGG144B	YGG144B	YGG144C
T_3	GG143A	GG143B	GG143C	YGG144B
T_4	YGG144B	YGG144B	YGG144C	YGG144C
T_5	YGGN144A	YGGN144B	YGGN144C	YGG144C

YGG= Yellow Green Group; GG= Green Group; T_1- Guar gum 0.5%, T_2- Guar gum 1%, T_3- Guar gum 1.5%,T_4- Guar gum 2%, T_5- Control

Table 5. Effect of nano coating (guar gum) on TSS (°brix) of Indian olive

Treatments	Days after treatments				
	0	3	6	9	12
T_1	9.96	9.37	8.27	7.45	6.90
T_2	9.99	9.46	8.25	7.65	6.95
T_3	9.97	9.97	8.78	8.34	7.65
T_4	9.98	9.55	8.37	8.08	7.23
T_5	9.99	8.84	7.57	7.03	6.14
SEm (±)	0.02	0.02	0.02	0.02	0.02
CD(0.05)	NS	0.06	0.05	0.07	0.06

T_1- Guar gum 0.5%, T_2- Guar gum 1%, T_3- Guar gum 1.5%, T_4- Guar gum 2%, T_5- Control

3.6 Titrable Acidity

The titrable acidity values of coated and uncoated fruit during storage decreased with storage time (Table 6). The value was found highest (0.61%) in T_3 on 12th days after treatment and the lowest (0.52%) in control (T_5). However, all the data were statistically significant under all the treatments from beginning to the end of storage. The low level of titrable acidity in control fruit compared to coated fruit suggests that the guar gum coating delayed ripening by providing a transparent coating around the fruit. It is also considered that coatings reduce the rate of respiration and may therefore delay the utilization of organic acids. Retention of titrable acidity has been reported previously for various fruit treated with edible coatings and films [23].

3.7 Total Sugar

Total sugar percentage is an important factor for determining the quality of Indian olive fruits. The flavour depends on total sugar percentage. It was decreased in all the treatments as the storage period advanced (Table 7). On 3rd days after treatment of sample, the total sugar content was found highest (8.34%) in T_3, where as it was lowest (7.89%) in the uncoated fruit. On 9th days after treatment, total sugar content was found maximum (7.85%) in T_3 where as it was minimum (7.14%) in T_5 (control). However all the treatments were statistically significant throughout the storage periods. The change of sugar content is occurred due to utilization of sugar as a respiratory substrate [25].

Table 6. Effect of nano coating (guar gum) on titrable acidity (%) of Indian olive

Treatments	Days after treatments				
	0	3	6	9	12
T_1	0.66	0.64	0.63	0.58	0.56
T_2	0.69	0.68	0.67	0.63	0.57
T_3	0.72	0.71	0.67	0.64	0.61
T_4	0.67	0.65	0.63	0.59	0.54
T_5	0.65	0.63	0.59	0.56	0.52
SEm (±)	0.02	0.01	0.01	0.01	0.02
CD(0.05)	NS	0.04	0.04	0.04	0.05

T_1- Guar gum 0.5%, T_2- Guar gum 1%, T_3- Guar gum 1.5%,T_4- Guar gum 2%, T_5- Control

Table 7. Effect of nano coating (guar gum) on Total sugar (%) of Indian olive

Treatments	Days after treatments				
	0	3	6	9	12
T_1	8.25	8.15	7.84	7.28	6.94
T_2	8.30	8.27	8.09	7.64	7.26
T_3	8.36	8.34	8.24	7.85	7.65
T_4	8.27	8.25	8.17	7.69	7.55
T_5	8.26	7.85	7.57	7.14	6.79
SEm (±)	0.03	0.02	0.02	0.02	0.02
CD(0.05)	NS	0.05	0.05	0.05	0.05

T_1- Guar gum 0.5%, T_2- Guar gum 1%, T_3- Guar gum 1.5%,T_4- Guar gum 2%, T_5- Control

3.8 Reducing Sugar

It can be observed from Table 8, that in general reducing sugar content showed a decreasing trend with the storage time (Table 8). The reducing sugar content was found highest (5.14%) in T_3 on 3rd days of storage whereas the lowest content (4.86%) was found in T_5. On 12th day of storage, T_3 showed highest (4.35%) result and the lowest (4.20%) result was observed in control. However, the data of all coated fruit were statistically significant throughout the storage periods. The changes in reducing sugar content are occurred might be due to utilization of sugar as a respiratory substrate [25].

Table 8. Effect of nano coating (guar gum) on reducing sugar (%) of Indian olive

Treatments	Days after treatments				
	0	3	6	9	12
T_1	4.99	4.95	4.85	4.64	4.34
T_2	5.08	5.05	4.97	4.84	4.27
T_3	5.16	5.14	5.05	4.85	4.35
T_4	5.12	5.10	5.03	4.75	4.31
T_5	4.89	4.86	4.81	4.54	4.20
SEm (±)	0.06	0.02	0.02	0.02	0.02
CD(0.05)	NS	0.05	0.05	0.05	0.06

T_1- Guar gum 0.5%, T_2- Guar gum 1%, T_3- Guar gum 1.5%, T_4- Guar gum 2%, T_5- Control

Table 9. Effect of nano coating (guar gum) on ascorbic acid (mg/ 100 g pulp) of Indian olive

Treatments	Days after treatments				
	0	3	6	9	12
T_1	48.97	47.95	46.15	45.07	43.15
T_2	48.97	48.37	46.17	45.20	43.25
T_3	48.97	48.86	46.73	45.23	43.95
T_4	48.98	48.45	46.27	45.20	43.45
T_5	48.97	47.57	45.94	44.67	43.14
SEm (±)	0.01	0.02	0.02	0.02	0.02
CD(0.05)	NS	0.06	0.06	0.06	0.05

T_1- Guar gum 0.5%, T_2- Guar gum 1%, T_3- Guar gum 1.5%, T_4- Guar gum 2%, T_5- Control

3.9 Ascorbic Acid

Observations on ascorbic acid content of Indian olive fruits presented in Table 9 revealed that all data were statistically significant under different treatments. The highest level of ascorbic acid (48.86 mg/100 g pulp) was observed in T_3, closely followed by fruits in T_4 (48.45 mg/100 g pulp) and the lowest level (47.57 mg/100 g pulp) in control fruit on 3rd days after storage. On 12th days of storage, it was observed maximum (43.95 mg/100 g pulp) and minimum (43.14 mg/100 g pulp) in T_3 and untreated fruits, respectively (Table 9). From the experimental result it is clear that coated fruits retained more amount of ascorbic acid. This was probably because guar gum coating acted as a gas barrier, inhibiting oxygen from entering the fruit, thus reducing the oxidation of ascorbic acid. Ascorbic acid is lost at later stage due to the activities of phenol oxidase and ascorbic acid oxidase enzymes during storage [26].

4. CONCLUSION

Application of guar gum coating could be beneficial in prolonging the postharvest life, maintaining fruit quality and antioxidant capacity (Ascorbic acid content) of Indian olive fruits. Besides this, coatings also protected the fruits from emergence of decay by delaying the senescence as compared to the uncoated fruits. From this, we can suggest that guar gum coatings (1.5% concentration) is very promising to extend the shelf life of Indian olive fruits.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Singh P, Sethi A, Nigam S, Srivastava B. Hot air drying characteristics of Indian olives (*Elaeocarpus floribundus*). National Conference on Emerging Technology Trends in Agricultural Engineering (ETTAE), NERIST, Nirjuli (Itanagar); 2014.
2. Bhowmick N. Some lesser known minor fruit crops of northern parts of West Bengal. Acta Horticulturea. 2011;890:61-64.
3. Artes F, Gomez PA, Artes-Hernandez F. Modified atmosphere packaging of fruits and vegetables. Stewart Postharvest Rev. 2006;2:1-13.
4. Tarafdar JC, Sharma S, Raliya R. Nanotechnology: Interdisciplinary science of applications. African Journal Biotechnology. 2013;12(3):219-226.
5. Espino-Díaz M, De Jesús Ornelas-Paz J, Martínez-Téllez MA, Santillán C, Barbosa-Cánovas GV, Zamudio-Flores PB, Olivas GI. Development and characterization of edible films based on mucilage of opuntia *Ficus indica* (L.). J Food Sci. 2010;75:347-352.
6. Hong K, Xie J, Zhang L, Sun D, Gong D. Effects of chitosan coating on postharvest life and quality of guava (*Psidium guajava* L.) fruit during cold storage. Scientia horticulturae. 2012;144:172–178.
7. Nurul-Hanani MZ, Halimahton-Zahrah MS, Zaibunnisa AH. Effect of chitosan-palm stearin edible coating on the postharvest life of star fruits (*Averrhoa carambola* L.) stored at room temperature. International Food Research Journal. 2012;19(4):1433-1438.
8. Ghosh A, Dey K, Bhowmick N, Medda PS, Dutta P. Effect of guar gum as an edible coating to improve Shelf life and quality of tomato (*Solanum lycopersicum* L.) fruits during storage. The Ecoscan. 2014;6:201-207.
9. Wijewardane RMNA. Application of polysaccharide based composite film wax coating for shelf life extension of guava (var. Bangkok Giant). International Journal of Postharvest Technology. 2013;1(1):16-21.
10. El-Anany AM, Hassan GFA, Rahab AFM. Effects of edible coatings on the shelf-life and quality of Anna apple (*Malus domestica* Borkh) during cold storage. J. Food Technol. 2009;7:5-11.
11. Mazumdar BC, Majumder K. Determination of chemical constituents. Methods on physico-chemical analysis of fruits. Daya Publishing House, Delhi. 2003;93-139.
12. Rangana S. Ascorbic acid. In. Manual Analysis of Fruit and Vegetable Products. Tata McGraw- Hill Publish. Comp. Ltd. New Delhi. 1977;94-101.
13. Gomez KA, Gomez AA. Problem data. Statistical procedures for agricultural research, 2nd edition. Wiley-Inter science Publication (John Wiley and Sons). New York, USA. 1983;275-315.
14. Russell OF. MSTAT-C v.2.1 (A computer based data analysis software). Crop and

Soil Science Department, Michigan State University, USA; 1994.
15. Baldwin EA, Burns JK, Kazokas W, Brecht JK, Hagenmaier RD, Bender RJ, Peris E. Effect of two edible coatings with different permeability characteristics on mango (*Mangifera indica* L.) ripening during storage. Postharvest Biology and Technology. 1999;17:215-26.
16. Oluwaseun AC, Arowora KA, Bolajoko FO, Bunmi AJ, Olagbaju AR. Effect of edible coating of carboxy methyl cellulose and corn starch on cucumber stored at ambient temperature. Asian J. Agri Biol. 2013;1: 133-40.
17. Tanada-Palmu PS, Grosso CRF. Effect of edible wheat gluten-based films and coatings on refrigerated strawberry (*Fragaria ananassa*) quality. Postharvest. Biology and Technology. 2005;36:199-208.
18. Rehman MU, Saravanan S, Mir MM, Umar I. Effects of carbohydrate and protein based edible coatings on quality of strawberry during storage. SAARC Journal of Agriculture. 2010;8:1–10.
19. ALI A, et al. Gumarabic as a novel edible coating for enhancing shelf-life and improving postharvest quality of tomato (*Solanum lycopersicum* L.) fruit. Postharvest Biology and Technology. 2010;58:42-47.
20. Sudha R, Amutha R, Muthulaksmi S, Baby Rani W, Indira K, Mareeswari P. Influence of pre and post-harvest chemical treatments on physical characteristics of sapota (*Achras sapota* L.) var. PKM-1. Res. J. Agri. Bio. Sci. 2007;3(5):450-52.
21. Ruzaina I, Norizzah AR, Halimahton Z, Cheow MS, Adi CS, Noorakmar MS, Mohd. Zahid A. Utilisation of palm – based and beeswax coating on the postharvest life of guava (*Psidium guajava* L.) during ambient and chilled storage. International Food Research Journal. 2013;20:265-74.
22. Smith SM, Stow JR. The potential of a sucrose ester coating material for improving the storage and shelf-life qualities of Cox's Orange Pippin apples. Ann. Appl Bio. 1984;104:383-91.
23. Yaman O, Bayoindirli L. Effects of an edible coating and cold storage on shelf-life and quality of cherries. Lebnsm Wiss Und Technol. 2002;35:46-50.
24. Özden C, Bayindirli L. Effects of combinational use of controlled atmosphere, cold storage and edible coating applications on shelf life and quality attributes of apples. Euro. Food Res. Tech. 2002;214:320–26.
25. Nandane AS, Jain RK. Effect of composite edible coating on physicochemical properties of tomatoes stored at ambient conditions. Indian Journal of Advanced Engineering Technology. 2011;2(4):211-17
26. Salunkhe DK, Boun HR, Reddy NR. Storage Processing and Nutritional Quality of Fruits and. Vegetables, In. Fresh Fruits Veg. Boston: CRC Press Inc; 1991.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/19904