Original Research Article

Effect of edible coating on shelf-life enhancement of papaya (*Carica papaya* L.) at ambient conditions

Abstract

An experiment was conducted on effect of edible coating on shelf-life enhancement of papaya (*Carica papaya* L.) at ambient conditions. The main objective of this study was to increase the shelf life of papaya by using edible coating. Postharvest losses in fruits is a serious problem due to rapid deterioration during storage. Use of edible coatings over fruits is used to improve their quality and enhance the shelf life. The main purpose of this study was to assess the effect of aloe vera gel, beeswax, paraffin wax and gelatine coating in extending the shelf-life of papaya including physico-chemical changes under ambient storage conditions. The experiment was laid out in completely randomized design (CRD) with 7 treatments and 3 replications. The treatment consisted of coating material with Aloe vera gel 0.5% (T1), Aloe vera gel 1%(T2), Aloe vera gel 1.5%(T3), Beeswax 6% (T4), Paraffin wax 100% (T5), Gelatin10%(T6), Control(T7) and freshly harvested papaya fruits. Statistical analysis revealed that among all the treatments, the maximum effect on extending the shelf-life and delaying the ripening was recorded in paraffin wax coated papaya fruits. Therefore, coating of papaya fruits with paraffin wax can be suggested as a post-harvest treatment to enhance the shelf-life.

Key words: Papaya, Edible coatings, Physico-chemical characteristics, Shelf-life

INTRODUCTION

Papaya (*Carica papaya* L.) is a tropical fruit belonging to the family caricaceae. Papaya is a nutritious table fruit of high digestive value and rich in vitamins and minerals. Papaya fruit are rich in enzymes called papain and chymopapain. Both enzyme digest protein, meaning they can help with digestion and reduce inflammation. Papaya is a highly nutritious and rich source of Vitamin A, B1, B2, E and C, minerals like potassium,

magnesium, boron, iron, calcium, and phosphorous, and copper. Further, it also contains 85-90% water, 10-13% sugar and 0.6% protein. The energy value of papaya is 200 kJ/100 g. Sugars present in papaya include glucose, fructose and sucrose. Papaya contains high level of anti-oxidants that reduce the risk of heart diseases. The anti-oxidants prevent the oxidation of cholesterol. Papaya has folic acid which is essential for converting the amino acid homo cysteine into less harmful amino acid.

Papaya is categorized as a climacteric fruit with an increased respiration rate during ripening process and its respiration rate can be inhibited by providing a coating on the surface of the fruit including aloe vera gel, beeswax, paraffin wax, gelatine etc.

Due to high perishable nature of papaya, a major portion of the production goes into waste which is reported to be around 40-60% of the total production at various papaya growing region (Prasad, K. and Paul, Joy., 2021). Increasing shelf life minimizes the loss of water, oxygen, and other soluble material from the fruits and vegetables. Edible coated fruits can have several advantages such as retention of colour, TSS, acidity, flavour for a longer period, reduction of post-harvest disorders; disease, therefore, increases the shelf life of the produce.

Aloe vera (*Aloe barbadensis* Miller) is a perennial plant of Liliaceae family with turgid green leaves joined at the stem in a rosette pattern. Aloe vera gel is tasteless, colourless and odourless. This natural product is a safe and environment friendly alternative to synthetic preservatives such as sulphur dioxide (Serrano *et al*., 2006).

Beeswax is derived from honeycomb and is produced by honey extraction. A study by Purwoko and Fitradesi (2000) showed that beeswax coating at 6% concentration can reduce weight loss and total soluble solids of papaya Solo cv Tainung compared to control after 14 days of storage.

Paraffin wax is a distillate of crude petroleum (Bennett, 1975) and is used for coating raw fruits and vegetables.

Gelatin, an important biopolymer obtained by hydrolysis from collagen, is widely used with a broad range of functional properties and applications such as in the food, pharmaceutical and photographic industries, including its film-forming ability. Gelatin films generally have effective barrier properties against oxygen and carbon dioxide. Aguilar-Mendez *et al*., (2008) found that the application of gelatin-starch coatings extended the postharvest shelf life of avocado.

The main purpose of this study was to assess the effect of aloe vera gel, beeswax, paraffin wax and gelatine coating in extending the shelf-life of papaya including physico-chemical changes at ambient storage condition. The study also aimed at analysing the physical and chemical changes in papaya during storage at ambient condition.

MATERIALS AND METHOD

The experiment on enhancing the shelf life of the papaya was conducted at Post Harvest Laboratory, Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology & Sciences, and PRAYAGRAJ (UP) during 2022.
The experimental design was CRD (Completely Randomized Design) with 7 treatments and 3 replications. Freshly harvested papaya fruit of variety red lady with uniform fruit shape and size was used. The coated fruits were kept at ambient condition for 15 days and observation on
Physiological loss in weight, total soluble solid, pH, vitamin C/ascorbic acid, titrable acidity, fruit colour, fruit texture, fruit taste, fruit appearance, fruit shelf life and fruit overall acceptability was taken at 3days interval.

The data recorded during the course of investigation were subjected to statistical analysis using CRD (Completely Randomized Design) as per the method of "Analysis of Variance" technique. The significant difference between the treatment's means were tested at 5% level of significance.
The overall significance of difference among the treatment was tested, using critical difference (C. D. at 5%) level of significance. The result was statistically analysed with the help of a window based computed package OPSTAT (Sheoran, 2004).

RESULTS AND DISCUSSION

Effect of edible coating on physiological loss of weight during storage in papaya:

The statistical analysis revealed significant difference among the different treatments studied.
The data is illustrated in Table1, which indicates that the treatment T5 (Paraffin wax) showed lowest physiological loss in weight (4.64%, 6.22%, 7.26%, 8.30% and 10.30%) at

3rd, 6th, 9th, 12th and 15th days of storage followed by Beeswax coating. Similarly, T7(control) indicates the highest physiological loss in weight of (7.51%, 8.33%, 10.22%, 12.18%, 13.86%).

Increase in PLW with the storage period might be due to loss of moisture from the fruits by way of transpiration or evaporation. The paraffin wax emulsion served as a physical barrier around the fruit which partially close the stomatal openings and lenticels thereby reduces the rates of transpiration and respiration **(Jain and Mukherjee 2011)**. The highest rate of PLW in control might be due to higher moisture loss humidity as compared to coated fruits **(Pongener *et al.*, 2011).**

Table 1: Effect of edible coating on physiological loss of weight during storage in papaya

TREATMENT	TREATMENT DETAILS	PHYSIOLOGICAL LOSS OF WEIGHT				
		NO. OF DAYS AT ROOM TEMPERATURE				
		INITIAL	6DAYS	9DAYS	12DAYS	15 DAYS
T_1	Aloe vera gel (0.5%)	6.36	7.34	9.34	10.20	12.59
T_2	Aloe vera gel (1%)	6.74	7.34	9.38	11.55	12.16
T_3	Aloe vera gel (1.5%)	6.59	7.39	9.22	10.36	11.58
T_4	Beeswax (6%)	5.23	6.39	7.40	8.22	10.51
T_5	Paraffin wax (100%)	4.64	6.22	7.26	8.30	10.30
T_6	Gelatin (10%)	5.74	6.34	7.38	9.22	10.85
T_7	Control	7.51	8.33	10.22	12.18	13.86
	C.D. at 5%	0.34	0.23	0.25	0.50	0.94

Effect of edible coating on total soluble solid during storage in papaya:

The statistical analysis revealed significant difference among the different treatments studied. The data is illustrated in Table 2, which indicates that the treatment T5 (Paraffin wax) showed the highest TSS of (9.99%) and lowest TSS was indicated in T7 control of (6.72%).

Total soluble solid of the papaya increased with the increase in storage period from 3rd day to12th day of storage and thereafter it decreased indicating rapid metabolic breakdown in those fruits. The increase in TSS during storage may possibly due to breakdown of complex organic metabolites into simple molecules or due to hydrolysis of starch into sugars. On complete hydrolysis of starch, no further increase in sugars occurs and subsequently a decline in these parameters is predictable as they along with other organic acids are primary substrate for respiration **(Wills *et al.* 1980).** The increase in TSS in wax coated fruits till 12th day and then gradual decrease as compared to control fruits indicating the possible role in delaying metabolic activities of fruits during ripening and storage **(Fan *et al.*, 1999).**

Table 2: Effect of edible coating on total soluble solid during storage in papaya

TREATMENT	TREATMENT DETAILS	TOTAL SOLUBLE SOLID (^{o} Brix)				
		NO. OF DAYS AT ROOM TEMPERATURE				
		INITIAL	6DAYS	9DAYS	12DAYS	15 DAYS
T_1	Aloe vera gel (0.5%)	6.40	7.71	9.02	10.33	7.30
T_2	Aloe vera gel (1%)	5.78	7.09	8.40	9.71	7.35
T_3	Aloe vera gel (1.5%)	5.46	6.77	8.11	9.35	7.35
T_4	Beeswax (6%)	5.11	6.42	7.73	9.01	7.69
T_5	Paraffin wax (100%)	4.75	6.06	7.37	8.61	9.99
T_6	Gelatin (10%)	5.15	6.46	7.77	9.04	7.39
T_7	Control	6.81	8.12	9.45	10.74	6.72
	C.D. at 5%	1.02	1.02	1.03	1.03	0.73

Effect of edible coating on pH during storage in papaya:

The statistical analysis revealed significant difference among the different treatment studied. The data is illustrated in Table 3, which indicates that the T7 (Control) showed highest pH value of (6.45) and lowest pH value was indicated in T5(6.11).

The pH of papaya increases during storage. An increase in pH papaya during storage was due to the conversion process of carbohydrate to sugar and the use of acids for metabolism. Similar findings have also been reported by **Suwanti *et al.*, (2018).**

Table 3: Effect of edible coating on pH during storage in papaya

TREATMENT	TREATMENT DETAILS	pH				
		NO. OF DAYS AT ROOM TEMPERATURE				
		INITIAL	6DAYS	9DAYS	12DAYS	15 DAYS
T_1	Aloe vera gel (0.5%)	4.73	5.30	5.65	5.76	6.26
T_2	Aloe vera gel (1%)	4.62	5.21	5.36	5.51	6.20
T_3	Aloe vera gel (1.5%)	4.49	5.20	5.31	5.41	6.15
T_4	Beeswax (6%)	4.35	5.33	5.44	5.50	6.12
T_5	Paraffin wax (100%)	4.36	5.28	5.40	5.50	6.11
T_6	Gelatin (10%)	4.43	5.26	5.44	5.53	6.15
T_7	Control	4.77	5.58	5.73	6.10	6.45
	C.D. at 5%	0.08	0.09	0.17	0.24	0.16

Effect of edible coating on vitamin C/ ascorbic acid during storage in papaya:

The statistical analysis revealed significant difference among the different treatment studied. The data is illustrated in Table 4, which indicates that the T5(paraffin wax) showed highest retention of vitamin C of (62.80 mg/100g) and lowest retention of vitamin C was indicated in T7 control (33.02 mg/100g). Vitamin C of papaya in all treatments increased until it reaches the peak maturity The fruits coated with paraffin wax show high retention of vitamin C due to retardation of oxidation process and consequently slow rate of conversion of L-ascorbic acid into dehydroascorbic acid by ascorbic acid oxidase. The retention of higher ascorbic acid in coated fruits might be due to the ripening retarding effect and slow rate of biological activities during storage. Similar observations have also been recorded in mango **Jain and Mukherjee *et al.*(2011)** and mandarin orange **Yadav *et al.*,(2010).**

Table 4: Effect of edible coating on vitamin C/ascorbic acid(mg/100gm) during storage in papaya

TREATMENT	TREATMENT DETAILS	VITAMIN C /ASCORBIC ACID (mg / 100g)				
		NO. OF DAYS AT ROOM TEMPERATURE				
		INITIAL	6DAYS	9DAYS	12DAYS	15 DAYS
T_1	Aloe vera gel (0.5%)	34.78	40.67	43.58	42.65	35.13
T_2	Aloe vera gel (1%)	35.12	40.54	43.50	42.56	35.20
T_3	Aloe vera gel (1.5%)	35.15	40.42	43.35	42.45	35.29
T_4	Beeswax (6%)	33.21	41.16	42.19	45.49	36.17
T_5	Paraffin wax (100%)	45.48	51.24	56.97	67.99	62.80
T_6	Gelatin (10%)	35.09	40.25	43.53	42.66	35.16
T_7	Control	35.32	40.66	45.71	42.82	33.02
	C.D. at 5%	0.58	0.59	0.79	0.39	0.69

Effect of edible coating on titrable acidity during storage in papaya:

The statistical analysis revealed significant difference among the different treatment studied.

The data is illustrated in Table 5, which indicates that the T5(paraffin wax) showed highest retention of titrable acidity of (1.70%) and lowest retention of titrable acidity was indicated in T7 control (1.45%). The titratable acidity of the fruits decreased with the increase of storage period. The decrease in TA with the increase in storage period could possibly be attributed due to the decreased hydrolysis of organic acids in pyruvate decarboxylation reaction occurring during the ripening process and subsequent accumulation of organic acids which were oxidised at a slow rate because of decreased respiration. Similar findings have also been reported by **Jain and Mukherjee *et al.*(2011)** and **Sarkar *et al.*, (1995).**

Table 5: Effect of edible coating on titrable acidity during storage in papaya

TREATMENT	TREATMENT DETAILS	TITRABLE ACIDITY (%)				
		NO. OF DAYS AT ROOM TEMPERATURE				
		INITIAL	6DAYS	9DAYS	12DAYS	15 DAYS
T_1	Aloe vera gel (0.5%)	1.17	1.29	1.43	1.66	1.51
T_2	Aloe vera gel (1%)	1.25	1.38	1.49	1.68	1.59
T_3	Aloe vera gel (1.5%)	1.32	1.39	1.52	1.71	1.59
T_4	Beeswax (6%)	1.42	1.52	1.63	1.77	1.65
T_5	Paraffin wax (100%)	1.51	1.65	1.72	1.82	1.70
T_6	Gelatin (6%)	1.37	1.47	1.57	1.66	1.59
T_7	Control	1.12	1.34	1.50	1.78	1.45
	C.D. at 0.5%	0.09	0.09	0.09	0.09	0.13

Effect of edible coating on taste during storage in papaya:

The statistical analysis revealed significant difference among the different treatment studied. The data is illustrated in Table 6, which indicates that the T5 (paraffin wax) showed highest retention of taste (7.46) followed by Beeswax (7.33) and lowest retention of taste was indicated in T7 Control (5.13). The papaya fruits showed a gradual and steady increase in the taste of the fruits up to 12th day of storage and after that a sharp decline was observed. The paraffin wax coated fruits were rated as extremely desirable after 12 day and thereafter taste declined. The gradual increase in the taste of papaya fruits during storage has been attributed to the increase in the concentration of total sugars and TSS contributing to the typical papaya taste. Similar findings have also been reported by **Hazarika *et al.*, (2017).**

Table 6: Effect of edible coating on taste of during storage in papaya

TREATMENT	TREATMENT DETAILS	TASTE				
		NO. OF DAYS AT ROOM TEMPERATURE				
		INITIAL	6DAYS	9DAYS	12DAYS	15 DAYS
T_1	Aloe vera gel (0.5%)	6.29	6.62	6.62	6.84	5.46
T_2	Aloe vera gel (1%)	6.33	6.57	6.57	6.71	5.36
T_3	Aloe vera gel (1,5%)	6.39	6.54	6.54	6.68	5.50
T_4	Beeswax (6%)	7.68	7.79	7.79	8.49	7.33
T_5	Paraffin wax (100%)	8.38	8.54	8.54	8.69	7.46
T_6	Gelatin (10%)	6.36	6.53	6.53	6.64	5.50
T_7	Control	5.67	6.11	6.11	6.52	5.13
	C.D. at 5%	0.16	0.19	0.19	0.15	0.27

Effect of edible coating on texture during storage in papaya

The statistical analysis revealed significant difference among the different treatment studied. The data is illustrated in Table.7, which indicates that the T5(paraffin wax) showed highest retention of texture (8.16) and lowest retention of texture in T7 control (5.69). The paraffin wax coatings of fruits resulted in higher fruit texture, which might be due to reduced transpiration and respiration activity along with delayed ethylene production and thus retained more turgidity of the cells of the fruits **Nanda *et al.* (2001).** Our study is in close conformity with the findings of **Sindhu *et al.* (2009)** in pear and **Singh *et al.*, (2011)** in passion fruit.

Table 7: Effect of edible coating on texture during storage in papaya

TREATMENT	TREATMENT DETAILS	TEXTURE				
		NO. OF DAYS AT ROOM TEMPERATURE				
		INITIAL	6DAYS	9DAYS	12DAYS	15 DAYS
T_1	Aloe vera gel (0.5%)	6.37	6.84	6.17	5.81	5.63
T_2	Aloe vera gel (1%)	6.50	6.71	6.30	6.22	5.83
T_3	Aloe vera gel (1.5%)	6.72	6.68	6.54	6.43	6.24
T_4	Beeswax (6%)	7.45	8.49	7.25	7.17	7.11
T_5	Paraffin wax (100%)	8.82	8.69	8.59	8.43	8.16
T_6	Gelatin (10%)	6.90	6.64	6.62	6.55	6.40
T_7	Control	6.82	6.52	6.48	5.86	5.69
	C.D. at 5%	0.25	0.15	0.18	0.19	0.17

Effect of edible coating on colour during storage in papaya:

The statistical analysis revealed significant difference among the different treatment studied. The data is illustrated in Table 8, which indicates that the T5 (paraffin wax) showed highest retention of colour which is (7.46) followed by T4 Beeswax (7.33) and lowest retention of colour was indicated in T7 control (5.13). In all the treatments, the colour of the fruits changed from green to yellow from the first day of storage (3rd day) till the end of storage period (16 day). In wax coated fruits, the development of yellow colour was at a slow and steady rate indicating more consumers preferred peel colour till the end of storage period. In wax coated fruits, the development of yellow colour increased at a slower rate till 15th day of storage resulting in development of uniform coloured fruit surface. Similar findings have also been reported by **Hazarika *et al.* (2017).**

Table 8: Effect of edible coating on colour during storage in papaya

TREATMENT	TREATMENT DETAILS	COLOUR				
		NO. OF DAYS AT ROOM TEMPERATURE				
		INITIAL	6DAYS	9DAYS	12DAYS	15 DAYS
T_1	Aloe vera gel (0.5%)	6.15	6.29	6.62	6.84	5.46
T_2	Aloe vera gel (1%)	6.21	6.33	6.57	6.71	5.36
T_3	Aloe vera gel (1.5%)	6.29	6.39	6.54	6.68	5.50
T_4	Beeswax (6%)	7.57	7.68	7.79	8.49	7.33
T_5	Paraffin wax (100%)	8.28	8.38	8.54	8.69	7.46
T_6	Gelatin (10%)	6.25	6.36	6.53	6.64	5.50
T_7	Control	5.40	5.67	6.11	6.52	5.13

	C.D. at 5%	**0.13**	**0.16**	**0.19**	**0.15**	**0.27**

Effect of edible coating on appearance during storage in papaya:

The statistical analysis revealed significant difference among the different treatment studied. The fruits treated with paraffin wax (T5) had gloss, shiny appearance and no wrinkles and browning, therefore scoring maximum value with respect to appearance (7.67) followed by T4 Beeswax (6.68) at 15 days of storage (Table 9). On the other hand, T7 control fruits registered the minimum appearance value (5.220). The development of better appearance in the wax coated fruits could be possibly due to creation of favourable gaseous atmosphere under congenial temperature. Our study is in close conformity with the findings of **Ladaniya *et al*. (2001)** in Mosambi sweet orange where the wax coated fruits had better appearance as compared other fruits.

Table 9: Effect of edible coating on appearance during storage in papaya

TREATMENT	**TREATMENT DETAILS**	**APPEARANCE**				
		NO. OF DAYS AT ROOM TEMPERATURE				
		INITIAL	**6DAYS**	**9DAYS**	**12DAYS**	**15 DAYS**
T_1	**Aloe vera gel (0.5%)**	**6.36**	**6.24**	**6.19**	**6.08**	**5.67**
T_2	**Aloe vera gel (1%)**	**6.50**	**6.39**	**6.29**	**6.19**	**6.08**
T_3	**Aloe vera gel (1.5%)**	**6.71**	**6.61**	**6.54**	**6.39**	**6.15**
T_4	**Beeswax (6%)**	**7.45**	**7.32**	**7.22**	**7.16**	**6.68**
T_5	**Paraffin wax (100%)**	**8.53**	**8.46**	**8.36**	**8.10**	**7.67**
T_6	**Gelatin (10%)**	**6.96**	**6.86**	**6.77**	**6.60**	**6.49**
T_7	**Control**	**6.83**	**5.63**	**5.49**	**5.40**	**5.22**

	C.D. at 5%	**0.28**	**0.27**	**0.26**	**0.26**	**0.20**

Effect of edible coating on overall acceptability during storge in papaya:

The statistical analysis revealed significant difference among the different treatment studied. The data is illustrated in Table 9, which indicates that the T5 (paraffin wax) showed highest score for overall acceptability which is (7.51) while, the lowest was observed in T7 control (4.610). The papaya fruits showed a gradual and steady decline in the overall acceptability of the fruits with the increase in storage period. The wax coated fruits were rated as extremely desirable after 12th day and thereafter taste declined. The overall acceptability of papaya fruits depends on a delicate balance of sugars, acids, phenolics and aromatic compounds with a number of additional factors such as pulp texture and visual appearance also influence the perceived quality and consumer acceptance and appreciation. Similar findings have also been reported by **Hazarika *et al.*, (2017).**

Table 10: Effect of edible coating on overall acceptability during storage in papaya

TREATMENT	**TREATMENT DETAILS**	**OVERALL ACCEPTABILITY**				
		NO. OF DAYS AT ROOM TEMPERATURE				
		INITIAL	**6DAYS**	**9DAYS**	**12DAYS**	**15 DAYS**
T_1	**Aloe vera gel (0.5%)**	**6.38**	**6.25**	**5.66**	**5.50**	**4.95**
T_2	**Aloe vera gel (1%)**	**6.81**	**6.65**	**6.38**	**5.66**	**5.35**
T_3	**Aloe vera gel (1.5%)**	**6.84**	**6.69**	**6.49**	**6.25**	**5.71**
T_4	**Beeswax (6%)**	**7.32**	**7.20**	**7.08**	**6.69**	**6.46**
T_5	**Paraffin wax (100%)**	**8.37**	**8.25**	**8.12**	**7.68**	**7.51**
T_6	**Gelatin (10%)**	**6.88**	**6.71**	**6.57**	**6.39**	**6.25**
T_7	**Control**	**6.30**	**5.70**	**5.65**	**5.33**	**4.61**

	C.D. at 5%	**0.04**	**0.12**	**0.24**	**0.204**	**0.29**

Effect of edible coating on shelf-life during storage in papaya:

The shelf-life of papaya fruits varied significantly among different treatments. Among all the treatments, fruits coated with paraffin wax T5 have maximum shelf-life of 18 days followed by T4 Beeswax 14 days and T3 Aloe vera gel 1.5% coatings with 10 days, while control recorded the lowest shelf-life of 6 days. The probable reason for paraffin wax coated fruits having maximum shelf-life might be due to its ability to serve as a physical barrier around the fruit which reduce transpiration and respiration activity along with delayed ethylene production.

In addition, waxing filled the lenticels and left no places for entry of pathogens like fungi and bacteria so ultimately it increases the shelf life of the papaya fruits. The positive effect of wax coating on storage life could probably due to the modifying the atmosphere. The modified atmosphere created could, therefore, delay the ripening by delaying ethylene production and by reducing the level of internal oxygen and consequently prolonging the storage life of papaya fruit **Gol and Rao *et al*., (2011).**

CONCLUSION:

Among all the tested treatments, paraffin wax has minimum PLW (10.30%), with high TSS value of (9.99^0brix), with maximum vitamin C content (62.80mg/100gm) and maximum titrable acidity of (1.70%). And in organoleptic parameters highest score for taste (7.467), texture (8.16), colour (7.46), appearance (7.67) and overall acceptability of (7.51) was also recorded in T5 (Paraffin wax). Among all the tested treatments, Paraffin wax has enhanced storage life capacity up to 18days and retained the nutritional quality as compared to the fruit of the control set. The maintenance of quality and extension of shelf life of papaya fruit by paraffin wax demonstrate that such a coating can be considered for commercial application during its storage.

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