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Enhancing seasonal fruit longevity: The role of innovative edible coatings

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Abstract- The main purpose of the study was to evaluate the potential of different kinds of edible coatings (i.e., coating A – corn starch 3%, coating B – corn starch + *Mentha viridis* L. (Mint), coating C – corn starch + *Ocimum tenuiflorum* L. (Tulsi), and coating D – corn starch + *Allium sativum* L. (Garlic) on the self-life of seasonal fruits like *Carica papaya* L. **(**Papaya), *Manilkara zapota* L. (Chikoo), *Musa acuminate* Colla. (Banana), and *Lycopersicon esculentum* Mill **(**Tomato). Edible coatings preserve the quality and extend the self-life of fresh fruits. Brushing techniques are used in applications of all four kinds of coatings. The fruits were analyzed for the quality parameters such as weight loss, color change and self–life. The studies show that the quality parameters of fresh fruits with surface edible coatings have better results than uncoated fruits. Compared to all the controls, all the coatings have positive effect on the fruits and among all the coatings coating – D corn starch + *Allium sativum* L. are highly effective and show great result as compared to other three coatings. It is concluded that the herbal edible coatings A- corn starch 3%, B - corn starch + *Mentha viridis* L., C – corn starch + *Ocimum tenuiflorum L.*, and D- corn starch + *Allium sativum* L. are useful for maintaining quality and extending self-life of fresh fruits. The herbal edible coatings are easily prepared from plant extract and are eco-friendly in nature and it is also very less costly so it is useful for people and farmers.

Key words: Herbal, Edible coating, Seasonal fruits, Self-life

INTRODUCTION

The fruits and vegetables are in highly demanded because of their nutritional value and health benefits. Vitamins, essential minerals, antioxidants, bio-flavonoids, dietary fibers, and flavor compounds are abundant in them, but they are susceptible to biotic and abiotic stresses.[1] According to the USDA and WHO, eating more fruits and vegetables promotes excellent health and helps to minimize the risk of disease.

One of India's agricultural sector's main problems is postharvest loss of agricultural products. The quality and age of storage are determined by the amount of moisture, odor, and flavor in the food.[2] The majority of foods ingested come straight from nature, and many of them can be eaten as soon as they are plucked from the tree, vine, or ground. However, transporting food products from one place to another takes time, and with the expansion of the transportation distribution system, storage demands, enormous supermarkets, and warehouse stores, foods are no longer consumed and it takes some period of time for a food product to reach the table of the buyer. Special protection is not provided to them and damage can occur in several days or hours and his is not immediately visible.[3] Many techniques and coatings, such as modified

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atmospheric packaging (MAP), controlled atmospheric packaging (CA), fungicides, and chemical preservatives, are already available and being used to extend the post-harvest life of fruits but these all methods are non-biodegradable, less cost-effective, and potentially harmful to human health.[4] The package is necessary to protect food product from environmental effects. Majority of the food products are packed with plastic materials, which contaminate the foods. If these foods are consumed, it increases the risk of cancer and other harmful disease.[2] Fruits are harvested at half-ripe stage if they are to be transported to distant place. Because of insufficient post-harvest and preservation techniques fruits are easily spoiled.[5] Post-harvest losses in India total over 2 lakh crore per year due to a lack of suitable storage and preservation facilities.[6]

Edible coating is a new and innovative technique which is developed for preserving the quality of fruits and vegetables by preventing color, texture, size, shape, appearance, aroma, and flavor changes. Edible coating is one of the most important alternatives and creative techniques used in the postharvest industry to extend the life of fresh fruits and vegetables after harvest.[7,8] Edible coatings are typically made from edible materials such as carbohydrates, protein, lipids, and their combinations, but when herbal extract are added so it's become more beneficial and known as herbal edible coating.[9]

MATERIALS & METHODS

Selection and harvest of fruits

Fresh, healthy and fully mature fruits like Papaya (*Carica papaya* L.), Tomato (*Lycopersicon esculentum* L.), Banana (*Musa acuminate* Colla) and Chikoo (*Manilkara zapota* L.) were plucked from the farms of village Adri, district Gir Somnath. The fruits were selected are mature, green, and free from disease. Before the application of edible coating fruits were washed thoroughly with hot water and dried at room temperature for few minutes.

Table 1: Preparation of herbal edible coatings

Coating A: Corn starch 3%	Coating B: Corn starch + Mint	Coating C: Corn starch + Tulsi	Coating D: Corn starch + Garlic
3% (w/v) of corn starch dissolved in 100ml of distilled water, mixed for 10-15 minutes at 90°C, maintain pH 5.6 by adding 50% citric acid solution and add 1.5 % glycerol as plasticizer.	**Preparation of leaves extract** Collect leaves and shade dried for 4-7 days then placed in hot-air oven at 65-70°C and powder was prepared by using mortar-pestle. 10g of leaves powder was added in 100ml of water in flask and after 24 hours mixer was filtered with Whatman No.1 filter paper and water evaporate in hot-air oven.[9,10]	**Preparation of leaves extract** Collect leaves and shade dried for 4-7 days then placed in hot-air oven at 65-70°C and powder was prepared by using mortar-pestle. 10g of leaves powder was added in 100ml of water in flask and after 24 hours mixer was filtered with Whatman No.1 filter paper and water evaporate in hot-air oven.[9,10]	**Preparation of bulb extract** Garlic bulbs which are free from disease were collected and peeled and washed with distilled water. Then garlic bulb was crushed by a clean mortar and pestle and this crushed garlic bulb was wrapped and squeezed by double layer clean cloth. Then the extract was filtered by Whatman No.1 filter paper and extract collected into sterile test tube. This extract was centrifuged at 1000 rpm for 10 minutes. The supernatant was filtered by Whatman No.1 filter paper.[11]
	Preparation of coating solution The herbal edible coating solution was prepared by addition of 2.5 gm corn starch powder and 1.5 gm mint leaves extract dissolved in 100 ml of distilled water with mixing for 10-15 minutes at 90°C. maintain pH 5.6 by adding 50% citric acid solution and add 1.5 % glycerol as plasticizer.[9]	**Preparation of coating solution** The herbal edible coating solution was prepared by addition of 2.5 gm corn starch powder and 1.5 gm tulsi leaves extract dissolved in 100 ml of distilled water with mixing for 10-15 minutes at 90°C. maintain pH 5.6 by adding 50% citric acid solution and add 1.5 % glycerol as plasticizer.[9]	**Preparation of coating solution** The herbal edible coating was prepared by adding 9.5% (w/v) corn starch powder is mixing in distilled water. The starch slurry was heated at 70°C for 20 minutes on magnetic stirrer. The dissolved suspension is filtered by a clean cloth and then maintains its temperature at room temperature. After that coating were prepared by mixing 0.5 ml garlic bulb extract and made volume up to 100 ml by adding distilled water.[11]

Coating of fruits with Edible coating solution

After the preparation of edible coatings solution, the fruits were coated with edible coatings. Brushing method was used for coating on experimental fruits. The fruits were divided into 2 parts control and experimental. After coating was completed all the experimental fruits and control were placed on the cardboard sheet. All the fruits were stored at the room temperature.

Determination of Physical Quality

1) Weight loss

The weight loss of fruits in each containment coating was assessed during the storage period by observing weight variations. The weight loss was calculated by dividing the difference between the beginning and final weights of the fruits by their original weight.[12]

2) Quality parameters

Fruit quality criteria were also examined based on the evolution of fruit skin color before and after coating with an edible coating solution according to below table.[13]

Table 2: Standard table for quality parameters

Quality Parameters	Method of Evaluation
Skin Color	Visual Index for Fruits:
	1 = Excellent
	2 = Good
	3 = Slightly dull
	4 = < 50% Brownish
	5 = > 50% Brownish

3) Self-life

The self-life of stored fruit was measured by adding up the days it took for them to reach the final stage of ripening, but only up to the point where they were still marketable.[14]

RESULTS & DISCUSSIONS

Effect of edible coating on Weight loss of Fruits

During this experimental study it can be observed that fruit shows progressive pattern of weight loss has been seen in both the coated and uncoated fruits. But there was a significant difference in the weight loss of coated and uncoated fruits at room temperature during storage period. Weight of the fruits was measured at interval of three days. According to Baldwin *et al.*, (1999)[15] the reduction in weight loss is probably because of the effect of the edible coating which is act as a semi permeable barrier against gases, moisture, and solute movement, to reduce respiration rate, water loss, and oxidation reduction rates. The results obtained respecting to weight loss of fruits are present in table:3 and it clearly indicate that there is increase in weight loss but fruits coated with edible coatings showed delay in weight loss as compared to uncoated fruits. During period of study, I have noticed that coating: D showed excellent result followed by coating: C & B showed good and moderate result. The data is similar to Radhav and Saini (2018)[9] who observed that on 12th day of coating application (Cornstarch + *Mentha viridis* L. (Mint)) on cucumbers cause delay in ripening and the minimum weight loss was seen in coating T1 and T3 (11.82% and 12.94% respectively) as compared to uncoated fruits. According to Vyas *et al*., (2014)[12], who also obtained results regarding to weight loss of papaya fruit also indicate that there is progressive increase in weight loss of papaya and this weight loss is continuously increase until the point when fruit reached fully ripened stage. However, papaya fruit coated with edible coatings showed delay in weight loss. It was observed that edible coating is useful for delayed decaying process. They Treated papaya fruit with 1% CMC and 1% carrageenan which shows that After 14 days of storage period and 21 days of storage period it was concluded that T1-treated (1%CMC) papaya fruit showed lesser weight loss percentage (9.6% and 13.6%, respectively). In contrast to 1% CMC the fruits treated with 1% carrageenan showed decrease in weight loss and till fresh at 21 day of storage period. According to Desta Dugassa, (2021)[11] used corn starch and *Allium sativum* L. (garlic) edible coating showed result that day 30 saw the most weight decrease of 9.06% for tomato fruits coated in corn starch. Conversely, the control sample showed a significantly ($P<0.05$) higher percentage of losses at each storage period, with day 30 showing the maximum loss of 14.71%.

In present experimental study the weight loss in all the tested fruits is increased with their storage period because of their continuous respiration and metabolism processes. Weight loss was determined by formula of AOAC[16] at interval of every three days.

Formula: -

$$\textbf{Weight loss } \% = \frac{Wi - Wf}{Wi} \times 100$$

Table 3: Fruits weight (weight is in grams)

	Day 1	Day 3	%	Day 9	%	Day 15	%	Day 17	%
Control									
Fruit 1 Papaya	770	745	3.24	659	14.41	558	27.23	514	33.24
Fruit 1 Banana	102	96	5.88	85	16.6	56	45.0		
Fruit 1 Chikoo	53	52	1.88	48	9.43	41	22.64		
Fruit 1 Tomato	78	77	1.28	74	5.12	67	14.1		
Coating A									
Fruit 2 Papaya	785	762	2.92	718	8.53	630	19.74	592	24.58
Fruit 2 Banana	103	98	4.85	87	15.5	67	34.9		
Fruit 2 Chikoo	72	71	1.38	67	6.94	61	15.27		
Fruit 2 Tomato	62	61	1.61	59	4.83	54	12.90		
Coating B									
Fruit 3 Papaya	792	773	2.39	733	7.44	656	17.17	623	21.33
Fruit 3 Banana	113	110	1.76	99	12.3	87	23.0		
Fruit 3 Chikoo	65	64	1.53	60	7.69	54	16.92		
Fruit 3 Tomato	89	88	1.12	86	3.37	79	11.23		
Coating C									
Fruit 4 Papaya	798	782	2.00	742	7.01	680	14.78	657	17.66
Fruit 4 Banana	112	110	1.78	101	9.82	89	20.5		
Fruit 4 Chikoo	62	61	1.61	59	4.83	53	14.51		
Fruit 4 Tomato	82	81	1.21	79	3.65	74	9.75		
Coating D									
Fruit 5 Papaya	767	750	2.21	721	5.99	658	14.21	635	17.20
Fruit 5 Banana	120	118	1.66	109	9.16	99	17.5		
Fruit 5 Chikoo	61	60	1.63	58	4.91	53	13.11		
Fruit 5 Tomato	79	78	1.26	76	3.79	71	10.12		

In the above tables it can be observed that fruit shows progressive pattern of weight loss from day one when experiment was carried out to the end of the experiment. Control fruits are ripe earlier and become decay however coating is helpful to enhance fruit self-life and reduce weight loss. Coating maid from 3 % corn starch are showed higher weight loss in all four kinds of fruits. *Carica papaya* L. coated with 3 % corn starch show 24.58 % weight loss, in banana 34.9%, in chikoo 15.27%, and in Tomato 12.90%, coating made up from combinations of cornstarch and *Mentha viridis* L. showed average result with 21.33% weight loss in papaya, in banana 23.0%, in chikoo 16.92%, in tomato 11.23%, coating of corn starch and *Ocimum tenuiflorum* L. have good result showed 17.66% weight loss in Papaya, 20.5% in Banana, 14.51% in chikoo and 9.75% in Tomato, and coating made up from corn starch and *Allium sativum* L. showed best result with 17.20% weight loss respectively in Papaya, 17.5% in Banana, 13.11% in chikoo and 10.12 % in Tomato.

Effect of edible coating on quality parameters of the fruits

Quality parameters are very useful to conclude quality of fruits. Changes in the skin color of fruits during storage not only determine the quality and age of the fruits but also serve as a key parameter for evaluating their overall freshness and ripeness at room temperature.[13] Standard parameters for quality are represent in table:2 and quality parameters of fruits represent in table: 4. It was observed at interval of three days. The numbering was given according to visual index of fruits. At 17th day of storage period quality parameters of Papaya (Slightly dull for coating C & D <50% Yellowish for coating: B and >50% Yellowish for coating: A). At 15th day of storage period quality parameters for banana and Chikoo (<50% Brownish for coating D & C and >50% Brownish for coating B & A). And at 15th day of storage period quality parameters of Tomato is (>50% for all four coatings). Pranita A. Gulhane, (2018)[17] also obtained similar kind of results. They assessed quality of fruits according to evolution in skin color of fruits before and after coating treatment. The obtained results regarding to skin color showed that apple is found in excellent in skin color while Tomato was good, and Papaya and Chikoo were slightly dull whereas banana was <50% brownish in color. Chauhan *et al.,* (2014)[13] also assessed quality and age of fruits by quality parameters. They Treated apple fruits with three different coating to enhance quality of fruit. Fruits were dipped in aloe vera gel (0%, 1%, 5%, 10%) marigold

flower extracts (0% ,10%, 20% and 30%) and neem oil (0%, 1% 2%, and 3%) for 5 min and stored in airtight container at 15°C for 45 days. *Aloe vera* gel show excellent result for all whereas marigold extract show excellent for 30%, good for 20% and slightly dull for 10% and neem oil show excellent result for 3% and good for 2% & 1%. Dey *et al.,* (2014)[18] used corn starch coating of different concentration (T1:0.5%, T2:1%, T3:1.5%, T4:2%, T5:2.5%, T6:3%). The experiment conducted for 9 days. The results analysis showed that sapota fruits are light grey when they're harvested. 9 days of following treatment all treated fruits were greyish orange colored except coating T6 and uncoated fruits which were greyish brown in color. They are determined that 2.5% corn starch coating show great result as compared to other coatings.

Table 4: Quality parameters of fruits

	Day 1	Day 6	Day 12	Day 15	Day 17
Control					
Fruit 1 Papaya	1	2	4	5	5
Fruit 1 Banana	1	3	5	5	
Fruit 1 Chikoo	1	3	5	5	
Fruit 1 Tomato	1	4	5	5	
Coating A					
Fruit 2 Papaya	1	2	4	5	5
Fruit 2 Banana	1	2	5	5	
Fruit 2 Chikoo	1	2	4	5	
Fruit 2 Tomato	1	4	5	5	
Coating B					
Fruit 3 Papaya	1	2	3	4	4
Fruit 3 Banana	1	2	4	5	
Fruit 3 Chikoo	1	2	4	5	
Fruit 3 Tomato	1	3	5	5	
Coating C					
Fruit 4 Papaya	1	2	2	3	3
Fruit 4 Banana	1	2	4	4	
Fruit 4 Chikoo	1	2	4	4	
Fruit 4 Tomato	1	3	5	5	
Coating D					
Fruit 5 Papaya	1	1	2	3	3
Fruit 5 Banana	1	2	3	4	
Fruit 5 Chikoo	1	2	4	4	
Fruit 5 Tomato	1	2	4	5	

Fruits' skin color changes as the storage period progresses due to the ripening process and different environmental factors. All fruit coated with 3% corn starch solution is become >50% Yellowish / Brownish and reddish at 15 days. Fruit coated with corn starch and *Mentha viridis* L. coating Papaya are become <50% Yellowish at 17 days and other three fruits are >50% Yellowish / Brownish and reddish at 15 days. Fruit coated with corn starch and *Ocimum tenuiflorum* L. coating Papaya is slightly dull at 17 days, Banana and Chikoo are <50% Yellowish /Brownish at 15 days and Tomato are >50% reddish at 15 days. And fruit coated with corn starch and *Allium sativum* L. coating help to maintain its quality and become slightly dull at 17 days in Papaya, Banana and Chikoo are <50% Yellowish /Brownish at 15 days and Tomato are >50% reddish at 15 days.

Effect of edible coating on self- life of the fruits

Self-life of fruits is simply calculated by counting days which required by fruits to attained last stage of ripening. But up to the point where fruits were still marketable.[12] Self-life of fruits is show in table:5. The results obtained during this period of study for self-life of fruits in *Carica papaya* L. fruit coated with Coating D - Corn starch + *Allium sativum* L. was extended to the maximum time of 17 days as compared to the other coated *Carica papaya* L. fruits and uncoated *Carica papaya* L. In the case of *Musa acuminate* Colla. fruit coated with Coating D - Corn starch +*Allium sativum* L. was extended to the maximum time of 13 days as compared to other coated *Musa acuminate* Colla fruits and uncoated *Musa acuminate* Colla. In the case of *Manilkara zapota* L. fruit coated with Coating D - Corn starch + *Allium sativum* L.

was extended to the maximum time 14 days as compared to other coated *Manilkara zapota* L. fruits and uncoated *Manilkara zapota* L. In the case of *Lycopersicon esculentum* Mill. fruit coated with Coating D - Corn starch + *Allium sativum* L. was extended to the maximum time of 12 days as compared to other coated *Lycopersicon esculentum* Mill. fruits and uncoated *Lycopersicon esculentum* Mill. These results are identical to Vyas *et al*., (2014)[12] who observed that increased level of CMC and carrageenan increase self-life of papaya up to 21 days. Papaya fruit coated with 1% CMC coating solution are extend self-life up to 21 days as compared to other coatings. Saini and Raghav, (2019)[19] also mentioned that fruit treated with edible coatings are survive for many days and their self-life are extend as compared to uncoated fruits. They use corn starch and *Ocimum sanctum* (Tulsi) coating for enhancing shelf-life of pears. Pears coated with herbal edible coating are stored at two different temperature (ambient temperature and low temperature 40°C) gave good results as compared to uncoated fruits, they concluded that it enhanced the shelf life of pears for 45 days at ambient temperature and 60 days at low temperature (40°C).

Table 5: Self-life of fruits

Fruits	Control	CA	CB	CC	CD
***Carica papaya* L.**	9	11	13	15	17
***Musa acuminate* Colla.**	7	9	10	11	13
Manilkara zapota	7	10	11	12	14
***Lycopersicon sculentum* Mill.**	6	9	9	12	13

CA: Coating A (Corn starch 3%) CB: Coating B (Corn starch +*Mentha viridis* L.)
CC: Coating C (Corn starch + *Ocimum tenuiflorum* L.) CD : Coating D (Corn starch + *Allium sativum* L.)

Table:6 Coating on *Carica papaya* L.

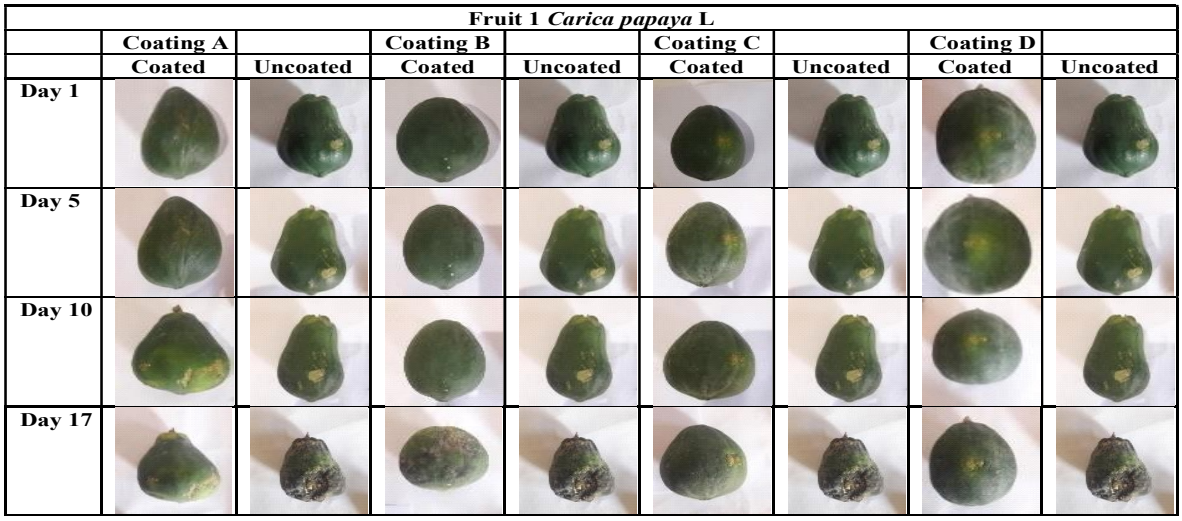


Table:7 Coating on *Musa acuminate* Colla

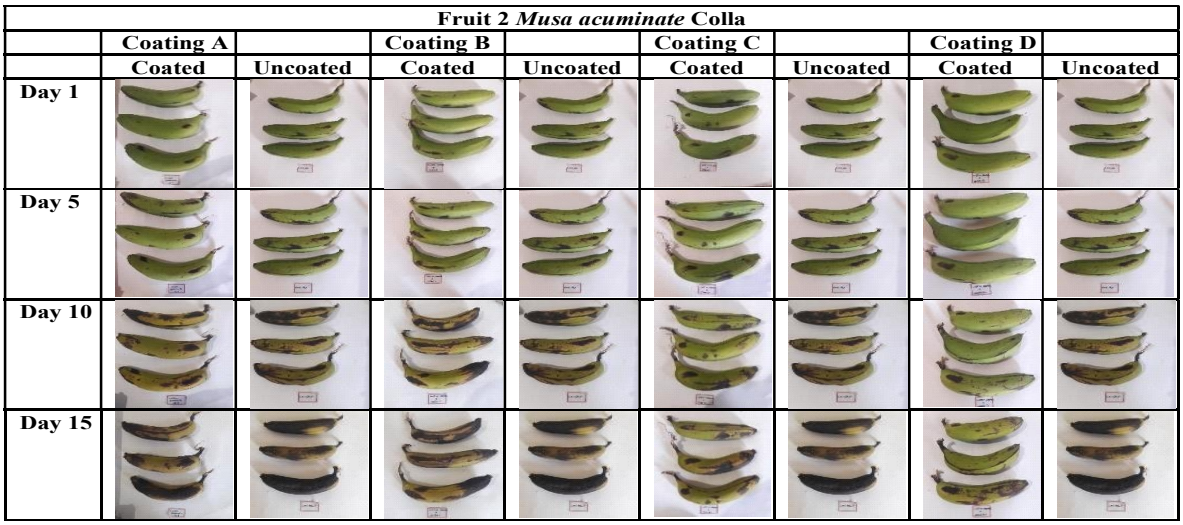


Table:8 Coating on *Manilkara zapota* L

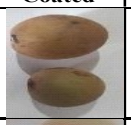
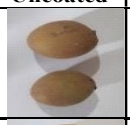
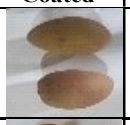
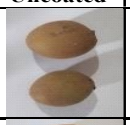
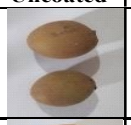
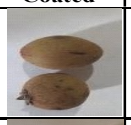
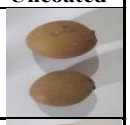
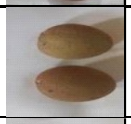
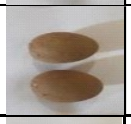
Fruit 3 *Manilkara zapota* L								
	Coating A		Coating B		Coating C		Coating D	
	Coated	Uncoated	Coated	Uncoated	Coated	Uncoated	Coated	Uncoated
Day 1								
Day 5								
Day 10								
Day 15								

Table:9 Coating on *Lycopersicon esculentum* Mill

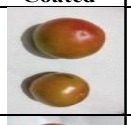
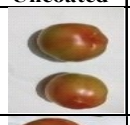
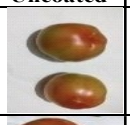
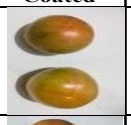
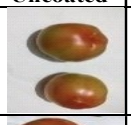
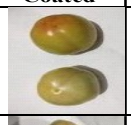
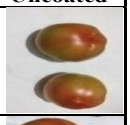
Fruit 4 *Lycopersicon esculentum* Mill								
	Coating A		Coating B		Coating C		Coating D	
	Coated	Uncoated	Coated	Uncoated	Coated	Uncoated	Coated	Uncoated
Day 1								
Day 5								
Day 10								
Day 15								

Fig 1: Graph of weight loss in fruits

During this period of experimental study, it can be concluded that both coated and uncoated fruits are showing progressive pattern of weight loss. During this comparative study of all four coatings determined that coated fruits show delayed in weight loss as compare to uncoated fruits. During storage period all four kinds of coatings are differently influenced on fruits. The comparison of influence of different coatings on different fruits are represent by graph in Fig 1. Graph show that coating D delayed weight loss in all four kinds of fruits. Coating C and B showed good and moderate result and coating A are not so effective in delay in weight loss process. The results obtained in present studied are identical to Saini and Raghav (2019)[19]. They prepared two different edible coatings by combining cornstarch and beeswax with aqueous Tulsi extract. Coated as well as uncoated pears fruits were stored at ambient temperature and low temperature (4°C). They made graph which shows that coated fruits excellently delay weight loss as compare to uncoated fruits. The sample that was coated with cornstarch and beeswax (T2, T5, T3, and T6) showed the least amount of weight loss (2.48, 1.47, 2.01 and 1.38 %), whereas the fruits were left uncoated (T1 and T4) showed the most weight loss (2.69% and 2.89%) at both ambient and low temperature.

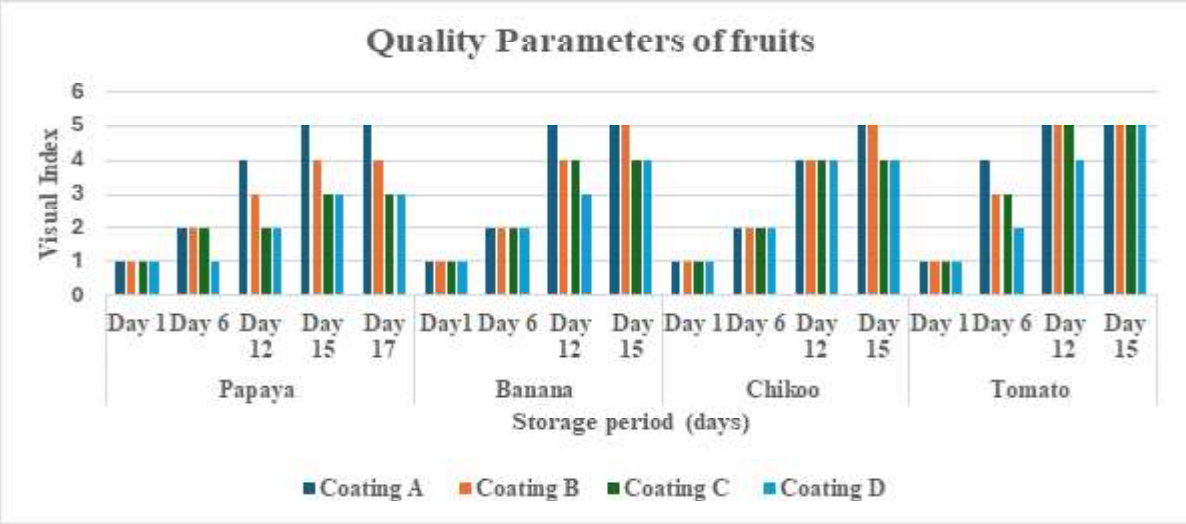


Fig 2: Graph of quality parameters of fruits

One of the best methods to evaluate fruits age as well as its quality is its visual appearance. Visual Index are used for find out fruit's quality by its visual observation. Influence of all kinds of coatings on different fruits are evaluate by parameters of visual index which are represent in graph of Fig 2. The graph clearly indicate that coating D give excellent result and maintain fruits skin color and keep fruits fresh for long period of time. Coating C and B also helpful to maintain fruits quality but coating A are not so effective to maintain quality of fruits.

CONCLUSIONS

Applications of surface edible coatings on seasonal fruits are shown notable delay in ripening process and minimizing the quality loss of Fruits at room temperature. Edible coating is a semi-permeable membrane act as barrier against environmental factor and also helps to reduced post-harvest issues like shriveling, rotting and wilting. Herbal edible coatings were significantly effective in reducing weight loss, maintain the visual appearance.

All four kinds of coatings which are prepared in this experimental study are effective to maintain quality, reduce weight loss and extending self-life of fruits. However, among all the coatings the fruits coated with coating- D Corn starch + Garlic (*Allium sativum* L) showed best result and retained the color, nutritional quality as compared to other coatings and control. Coating – C corn starch + Tulsi (*Ocimum tenuiflorum* L) showed good result and help to maintain quality and reduce weight loss, coating – B corn starch + Mint (*Mentha viridis* L) showed moderate result and help to maintain quality and reduce weight loss, coating – A corn starch 3% showed low result. fruits coated with corn starch 3% showed maximum weight loss and lower quality maintain. Therefore, on the basis of this study it can be concluded that the herbal edible coating was an

effective and healthy source used for enhancement of self-life of fresh fruits.

All four kind of coating showed positive result in bellowed manner

Coating –D> Coating – C > Coating – B> Coating > A

The coatings which are prepared in this experimental study are non-toxic and eco-friendly and have no harmful effect. The coatings are made from plant extract which are beneficial for health and also as medicine. The coatings are used commercially during storage and marketing. These coatings are much useful to the farmers which have very less cost efficiency and can be easily available in nature as they are extracted from the natural plant extract.

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