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INFLUENCE OF DIFFERENT SURFACE COATINGS ON PHYSICAL ATTRIBUTES OF APPLE BER FRUIT

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ABSTRACT

The present study was conducted to analyze the influence of different surface coatings on the shelf life of apple ber fruit at School of Agriculture, ITM University, Gwalior in the year 2023-24. Thirteen treatment combinations of surface coating material and nanoparticles were applied on apple ber fruits to check their effects on fruit weight, polar diameter, equator diameter, fruit stone ratio, specific gravity and physiological loss in weight of apple ber fruits. The experiment was laid in Completely Randomized Design with three replications in each treatment. The treatments consisted T1- Chitosan(1%), T2- Chitosan (1%) +$AgnO_3$ NP (50ppm), T3- Chitosan (1%) +TiO_2 NP (50ppm), T4- Paraffin wax (5%), T5- Paraffin wax (10%), T6- Carnauba wax (5%), T7- Carnauba wax (10%), T8- Coconut oil, T9- Aloe vera + $AgNO_3$ NP (50ppm), T10- Aloe vera + TiO_2 NP (50ppm), T11- Aloevera, T12- $CaCl_2$ (2%) and T0-control. Out of all the treatment combinations, treatment T_5 (Paraffin wax (10%) proved to be the best treatment for enhancing the shelf life of apple ber fruits and reducing the post-harvest losses to a great extent.

***Key words*: Apple Ber, physical attributes, shelf life, surface coating**

Introduction

The Apple Ber or Jujube (*Ziziphus mauritiana* Lam.) is one of the most ancient cultivated fruit trees grown in North Indian plains. It belongs to the family Rhamnaceae with chromosome number 2n=48. It is originated in Thailand and slowly distributed in many parts of the world. It is found growing wild as well as in cultivated forms throughout the warmer reasons up to an altitude of 1500 meter above mean sea level (Pareek, 2001). It is one of the most important minor fruit crops of arid and semi-arid regions of India. In India total area of Ber was 53 thousand ha and recorded the total production 5.80 lakh MT (Anonymous, 2024). Apple Ber cultivation first started in Maharashtra and afterwards got distributed in the other states of the country.

Ber is a climacteric fruit &it is also known as “poor men`s apple” because it has nutritional benefits like apple and economically reasonable to poor people (Mathangi and Maran, 2004). Apple Ber is very attractive, sweet, crispy and juicy. It is generally consumed as fresh. Several types of processed products can also be prepared from it. It is a good source of minerals, antioxidants, and antimicrobial compounds. The ripening and senescence of the fruit is triggered by ethylene, resulting a short shelf life and prone to browning and decay. Ber fruit are highly perishable and suffer heavy losses after their harvest, particularly during postharvest handling. The high rate of respiration, enhanced ethylene biosynthesis, cell wall softening, pathogen susceptibility, etc are some of the major physio-biochemical changes associated with these losses, reducing the market value of the produce (Lal *et al.,* 2002). Because of its elevated respiration rate and other enzymatic activities during storage, fresh fruit accelerate physiological weight loss and decay (Wang *et al.,* 2011). Various tactics, including packaging, chemical preservatives, modified storage environments, and refrigeration, have been implemented to mitigate harmful effects (Zhang and Quantick, 1997).

Due to surplus production of fruits, there is a glut in the local market during its peak season, a huge quantity goes waste resulting the heavy post-harvest losses. Several techniques like refrigeration, modified atmospheric storage, preservation and packaging are being used to minimize the losses (Zhang and Quantick, 1970). Edible coatings and films are a much cheaper alternative when compared with the other expensive techniques that are seldom used in shelf -life extension of fresh produce (Baldwin *et al.*, 1995). Efficiency of edible coatings on fruit and vegetables documented as a method usually for preventing perishable food items by decay up to a certain time. A very thin layer of edible material protects fruits from desiccation, uptake of oxygen and loss of other volatile material from inside the fruit.

Some of the lipids that have been used effectively in coating formulations are beeswax, mineral oil, vegetable oil, surfactants, acetylated monoglycerides, carnauba wax and paraffin wax (Kester and Fennema, 1986). Lipids offer limited oxygen barrier properties, due to the presence of microscopic pores and elevated solubility and diffusivity. Lipid films have good water vapor barrier properties, due to their low polarity, but are usually opaque and relatively inflexible (Guilbert *et al.,* 1996).Wax, the first edible coating known is the most effective coating to block moisture migration. There are number of waxes used but the most effective one is paraffin wax, followed by beeswax (Park, 1999). The resistance is related to their compositions. Paraffin wax consists of a mixture of long-chain saturated hydrocarbons while beeswax comprises a mixture of hydrophobic, long chain ester compounds, long chain hydrocarbons and long chain fatty acids. The absence of polar groups in paraffin and low levels in bees wax account for their resistance to moisture transport.

Paraffin wax is derived from distillate fraction of crude petroleum and consists of a mixture of solid hydrocarbon resulting from ethylene catalytic polymerization. Paraffin wax is used a barrier films to gas and moisture and to improve the surface appearance of various fruits and vegetables. If applied as a thick layer, they must be removed before consumption and when used in thin layers, they considered edible. Waxes (notably paraffin, carnauba, candellila and bee wax) are the most efficient edible compounds providing a humidity barrier permitted for use on raw fruits and vegetables and cheese.

They obtained satisfactory results with waxed fruits of Dashehari and Langra as compared to control. It was noted that the paraffin wax @ 6% was the best in terms of storage life and marketability of fruits. Similar results were obtained by Singh *et al.*, (1993) in guava *cv*. Allahabad Safeda. Tarkse and Desai (1989) studied the response of wax emulsion, growth regulators, bavistine; perforated polythene bags alone or in combination treatment with wax emulsion to be the best in terms of storage life and other traits.

Materials & Methods

The present study was conducted at Department of Horticulture, School of Agriculture, I.T.M. University, Sitholi, Gwalior, Madhya Pradesh. The experiment was laid in Completely Randomized Design having thirteen treatments and three replications. Treatment details are T1- Chitosan(1%), T2- Chitosan (1%) +$AgnO_3$ NP (50ppm), T3- Chitosan (1%) +TiO_2 NP (50ppm), T4- Paraffin wax (5%), T5- Paraffin wax (10%), T6- Carnauba wax (5%), T7- Carnauba wax (10%), T8- Coconut oil, T9- Aloe vera + $AgNO_3$ NP (50ppm), T10- Aloe vera + TiO_2 NP (50ppm), T11- Aloevera, T12- $CaCl_2$ (2%) and T0-control.

Collection of fruits: Fruits were collected from the local fruit market of Gwalior. Fresh, fleshy, mature and green fruits were selected for the experiment.

Coating material: Chitosan, paraffin wax, calcium chloride was collected from laboratory of Department of Horticulture, School of Agriculture, I.T.M. University Gwalior. Aloe-vera leaves was collected from government Tapovan nursery, Gwalior. Coconut oil was purchased from the local grocery shop at Gwalior. Silver nanoparticles and titanium nanoparticles purchased from the market.

Coating of fruits: All coatings for required concentration were prepared for each treatment. Fruits were dipped in each treatment for 5 minutes.

Storage of fruits: Coated fruits were placed in plates and kept at room temperature. The duration of storage was 20 days and observations were recorded in regular interval of 4 days.

Fruit weight (g): Three fruits per treatment were weighed on an electronic balance and average weight (g) was obtained by dividing the total weight of the fruits with the number of fruits.

$$\text{Average fruit weight} = \frac{\text{Total weight of fruits (g)}}{\text{Number of fruits}}$$

Diameters: polar and equator diameters was measured in mm with the help of verniercallipers.

Specific gravity (g cm^{-3}): The specific gravity was calculated by dividing the fruit weight with fruit volume.

$$\text{Specific gravity} = \frac{\text{Fruit weight}}{\text{Fruit volume}}$$

Fruit stone ratio: It was calculated by dividing fruit weight with fruit stone weight.

$$\text{Fruit stone ration} = \frac{\text{Weight of fruit}}{\text{Weight of stone}}$$

Physiological loss in weight (PLW) (%): Physiological loss in weight was expressed in percentage. It was calculated by using the following formula.

$$\text{PLW (\%)} = \frac{\text{Initial weight - Final weight}}{\text{Initial weight}} \times 100$$

Statistical Analysis

The data were obtained in triplicates (n=3) for each parameter and their mean was calculated. Data significantly was analyzed statistically using one-way ANOVA. F-test was adopted for the level of significance at 5%. Standard error of difference (SEd) and Critical difference (CD) were also obtained.

Result & Discussion

Fruit weight (g): The fruit weight was observed to be decreasing with the increasing number of storage days irrespective of the treatment combinations. The highest fruit weight at 0, 4th, 8th, 12th, 16th and 20th days was observed in treatment T_5 (Paraffin wax (10%) with 65.90g, 65.19g, 64.90g, 62.60g, 59.97g and 56.67g respectively. Followed by treatment T_8 (Coconut oil) with 64.11g, 63.48g, 62.18g, 58.97g, 55.77g and 53.21g at different intervals of observation, while the lowest fruit weight was recorded in treatment T_0 (control) with 64.40g, 62.20g, 59.24g, 53.45g, 48.30g and 46.36g respectively at different intervals. The results are in accordance to Hu *et al.*, (2011) who studied the effects of two types of waxing treatment (Sta-Fresh 2952 wax and Sta-Fresh 7055 wax) on pineapple fruits cv. 'Paris'. Result showed that the weight loss of both control and wax-treatment increased continuously with storage time. The weight loss of control was significantly greater than that of wax-treatment on the 7th and 14th day of storage. At the end of the storage, the control showed 3.1% loss in weight, whereas the weight loss in wax treated fruits were 2.6%. Fig. 1 represents the fruit weight at different treatment combinations.

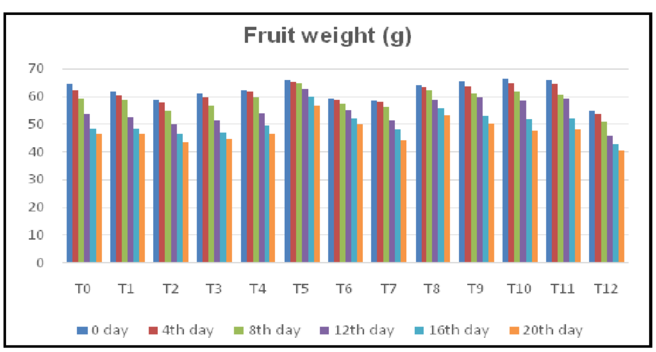

Fig. 1: Effect of different surface coatings on fruit weight of apple Ber.

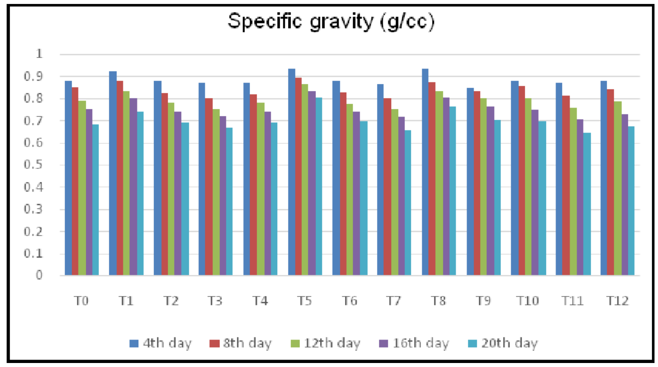

Fig. 2: Effect of different surface coatings on specific gravity of apple ber.

Polar diameter (mm): The polar diameter or length of the fruits was found reducing with increased number of storage days. The maximum polar diameter with minimum shrinkage percentage was recorded in treatment T_5(Paraffin wax (10%) with 51.33mm, 50.00mm, 48.00, 46.33mm, 45.00mm and 43.33mm weight at 0, 4th, 8th, 12th, 16th and 20th days after coating with minimum shrinkage percentage of 15.57%. Followed by treatment T_8 (Coconut oil) with 52.00mm, 50.00mm, 47.66mm, 45.83mm, 43.66mm and 41.83mm with 19.55 shrinkage percentage at different intervals of observation, while the minimum polar diameter of apple ber fruits was recorded in treatment T_0 (control) with 53.67mm, 51.67mm, 45.00mm, 42.00mm, 39.00mm and 36.66mm with a maximum shrinkage percentage of 31.68 at various observation intervals. The results are in agreement with Bisen *et al.*, (2012) who reported that wax coating increased the firmness of fruit cell wall, retarded the rate of respiration, transpiration, decay and reduced the enzymatic activities responsible for disorganization of cellular structure, thus, delayed senescence and thereby, reduced weight loss. Table 1 represents the polar diameter of apple ber fruits at different treatment combinations.

Equator diameter (mm): The equator diameter or width of the fruits was observed to get reduced with increased number of storage days. The minimum equator

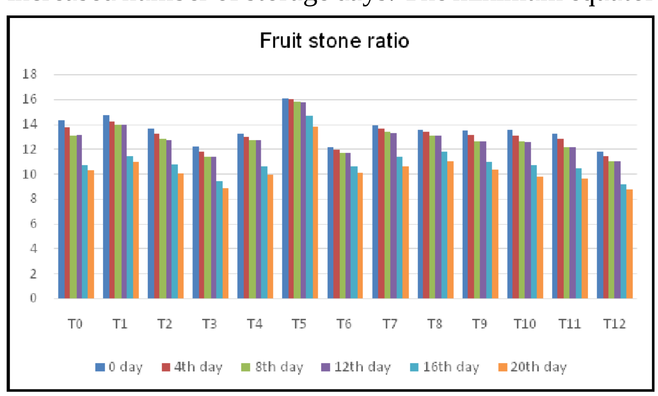

Fig. 3: Effect of different surface coatings on fruit stone ratio of apple ber.

Table 1: Effects of different surface coatings on polar diameter of fruits.

Treat-ment	0-day (mm)	4th day (mm)	8th day (mm)	12th day (mm)	16th day (mm)	20th day (mm)	Shrinkage (%)
T_0	53.67	51.67	45.00	42.00	39.00	36.66	31.68
T_1	54.33	50.33	47.33	44.16	41.70	39.66	26.98
T_2	52.67	50.67	48.00	45.13	43.00	40.83	22.47
T_3	52.67	49.67	46.66	44.00	41.66	39.00	25.95
T_4	52.00	50.00	45.33	42.53	40.00	38.00	26.92
T_5	51.33	50.00	48.00	46.33	45.00	43.33	15.57
T_6	50.00	47.67	46.00	44.00	42.00	40.16	19.66
T_7	50.00	46.33	43.00	40.66	37.66	35.66	28.66
T_8	52.00	50.00	47.66	45.83	43.66	41.83	19.55
T_9	52.00	49.00	45.83	43.33	40.00	38.03	26.85
T_{10}	50.00	47.33	43.66	41.26	39.66	37.60	24.80
T_{11}	53.33	50.00	46.96	44.00	40.83	39.00	26.87
T_{12}	54.00	50.33	47.16	44.33	41.06	39.00	27.77
C.D.	1.212	1.212	1.664	1.942	1.849	1.707	
SE(m)	0.415	0.415	0.569	0.664	0.632	0.584	

Table 2: Effects of different surface coatings on equator diameter of fruits.

Treat-ment	0-day (mm)	4th day (mm)	8th day (mm)	12th day (mm)	16th day (mm)	20th day (mm)	Shrinkage (%)
T_0	47.00	45.33	42.00	39.50	36.50	33.33	29.78
T_1	45.33	43.33	41.00	38.80	36.66	34.33	24.25
T_2	45.66	43.33	40.33	38.16	36.33	33.33	27.01
T_3	46.33	44.00	41.00	39.00	37.00	34.66	25.17
T_4	49.00	45.33	43.66	41.40	39.66	36.66	25.17
T_5	49.00	47.67	46.33	45.33	43.70	42.33	13.60
T_6	46.66	44.67	42.66	41.00	39.33	37.33	20.00
T_7	46.33	44.00	41.33	39.23	36.66	34.00	26.61
T_8	49.00	47.00	45.00	43.33	41.66	39.66	19.04
T_9	47.66	45.00	42.53	40.33	37.73	35.33	25.87
T_{10}	48.00	46.00	42.23	40.33	38.00	35.80	25.41
T_{11}	48.66	46.33	44.00	41.33	39.03	36.66	24.66
T_{12}	45.66	44.00	40.33	38.33	36.00	33.73	26.13
C.D.	N/A	1.212	3.102	2.919	2.192	2.219	
SE(m)	1.622	0.415	1.061	0.999	0.75	0.759	

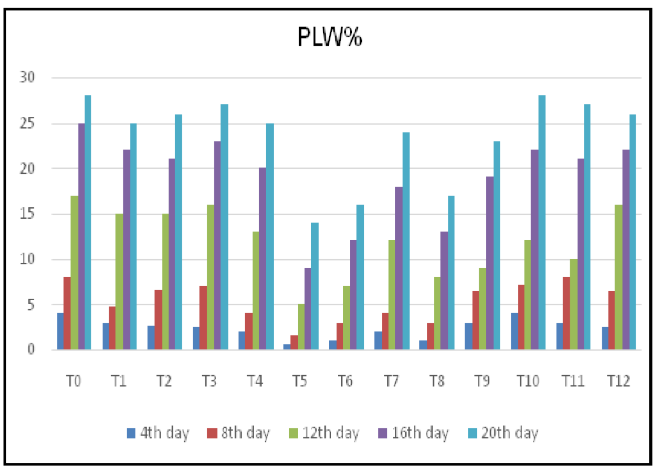

Fig. 4: Effect of different surface coatings on PLW%.

diameter of fruits was recorded in treatment T_0 (control) with 47.00mm, 45.33mm, 42.00mm, 39.50mm, 36.50mm and 33.33mm with highest shrinkage percentage of 29.78 at 0, 4th, 8th, 12th, 16th and 20th days after coating. Whereas, the maximum equator diameter was recorded in treatment T_5 (Paraffin wax (10%) with 49.00mm, 47.67mm, 46.33mm, 45.33mm, 43.70mm and 42.33mm with lowest shrinkage percentage of 13.60 at different intervals, followed by treatment T_8 (Coconut oil) with 49.00mm, 47.00mm, 45.00mm, 43.33mm, 41.66mm and 39.66mm with a shrinkage percentage of 19.04. the results are in accordance to El Anany *et al.*, (2009) who conducted the study on Anna apple by coating different edible materials after an interval of 15 days up to 60 days during cold storage (0°C, 90-95% RH) to see the effect on shelf life and quality. The coated apples showed a significant delay in the change of weight loss as compared to uncoated ones. The weight loss of apple fruits with paraffin oils (99%) was 3.94% at 60 days of storage as compared with 5.82% in case of control. This 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. Table 2 represents the equator diameter of apple ber fruits at different treatment combinations.

Specific gravity (g cm^{-3}): The specific gravity of the fruits was found decreasing with increased number of storage days irrespective of the treatment combinations. The maximum specific gravity at 4th, 8th, 12th, 16th and 20th days after coating was observed in treatment T_5 (Paraffin wax (10%) with 0.99g cm^{-3}, 0.89g cm^{-3}, 0.86g cm^{-3}, 0.83g cm^{-3} and 0.80 g cm^{-3}, followed by treatment T_8 (Coconut oil) with 0.93 g cm^{-3}, 0.87 g cm^{-3}, 0.83 g cm^{-3}, 0.80 g cm^{-3} and 0.76 g cm^{-3}. The results are in accordance with Ketsa and Prabhasavat (1992) who investigated the effect of Semper fresh skin coating on shelf life and quality of' Nang Klangwan' fruit of mango. At ambient temperature 32°C and RH 74.0 percent, the weight loss, firmness, yellow color development and the chemical changes related with ripening were observed in waxed and non-waxed mango fruits. The Semper fresh- waxed 1%

extended the shelf life of mango by 14 days, while the shelf life of non-waxed mango fruits was 10 days. Fig. 2 represents the specific gravity of fruits at different intervals.

Fruit stone ratio: The fruit to stone ratio was found to be decreasing gradually with the increase in the number of storage days irrespective of the treatment combinations. It was observed that the maximum fruit stone ratio at 0, 4th, 8th, 12th, 16th and 20th days of the storage duration was recorded in treatment T_5 (Paraffin wax (10%) with 16.07, 15.99, 15.83, 15.74, 14.63 and 13.82. followed by treatment T_8 (Coconut oil) with 13.50, 13.36, 13.06, 13.07, 11.74 and 11.04 at different intervals. While the minimum fruit to stone ratio was recorded in treatment T_{12} ($CaCl_2$ 2%) with 11.77, 11.48, 11.01, 11.01, 9.18 and 8.71. The findings are in accordance with Sarkar *et al.* (1995) who reported that the fruits treated with wax emulsion 3 and4% could be stored up to 10 days. It was also found that by increasing the wax concentrations with triethanolamine as emulsifying agent, the shelf life of fruits could be increased. Fig. 3 shows the tabular representation of fruit stone ratio at different treatment combinations.

Physiological loss in weight (PLW) (%): The weight of the fruits was found reducing gradually with the increased number of days, which resulted in increased percentage of physiological loss of weight with time. The minimum percentage of physiological loss of fruit weight 14.00 was found in treatment T_5 (Paraffin wax (10%) with 0.50%%, 1.50%, 5.00%, 9.00% and 14.00% at 4th, 8th, 12th, 16th and 20th days after coating. Followed by treatment T_6 (Carnauba wax 5%) with a total of 16.19% physiological loss of weight. The findings are in accordance with Rajkumar *et al.*, (2008), who found that PLW varied between 7.83% and 13.15% for the wax emulsion coated mango fruits after 12th day of storage. They observed that, wax emulsion @ 6% recorded the lowest PLW of 7.83% followed by (5%) wax emulsion after 12 days of storage period. At the same time, the unwaxed (control) mango fruits recorded the highest PLW of 18.46%. Fig. 4 represents the PLW% of fruits at various intervals.

Conclusion

From the present study it tends to be concluded that Paraffin wax (10%) proved to be to most effective coating material to increase the shelf life of apple ber fruits. The quality of fruits in terms of fruit weight, fruit length, and fruit width, physiological loss in weight, fruit stone ratio, and specific gravity were significantly affected by paraffin wax during storage period. Paraffin wax coating at 10% significantly worked to minimum reductionof fruit weight, diameter, fruit stone ratio and specific gravity of the fruits of apple ber.

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