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Improvement of Shelf Life and Quality of Mango (*Mangifera indica*) by Edible Coatings

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Abstract

Mango (*Mangifera indica*), considered to be a member of the Anacardiacae family, is a significant tropical fruit crop with potential markets. After being harvested, mangoes ripen rapidly, which reduces their potential for handling, storing, and transportation. The experiment on the improvement of shelf life and quality of mango by edible coating was laid out in a randomized design (CRD) with ten treatments and three replications. The treatments consist of T_1-Honey Bee Wax 10%, T_2-Honey Bee Wax 25%, T_3-Honey Bee Wax 30%, T_4-Aloe Vera Gel 10%, T_5-Aloe Vera Gel 25%, T_6-Aloe Vera Gel 30%, T_7-Gelatin 10%, T_8-Gelatin 25%, T_9-Gelatin 30%, and T_{10}-Control. The observations on physiological parameters, biochemical parameters, and organoleptic evaluations were recorded on the on the 3rd, 6th and 9th days after treatment. The results revealed that the mango treated with T_3 (Honey Bee Wax 25%) significantly reduced the physiological loss in weight (0.19, 0.25, and 0.33%) and maximum TSS of 9.29, 10.88, and 14.14 brix, respectively. The lowest spoilage loss at 6th (0.45) and 9th day (0.69), maximum days taken for shriveling initiation (10.50 days), and maximum shelf life (16.35 days) were recorded when the mango fruits were treated with Honey Bee Wax 25% compared to other treatments. Organoleptic characters like fruit color, pulp color, taste, aroma, and overall acceptability showed the maximum scores in treatment T_3 (Honey bee Wax 25%). Honey bee Wax 25% was found to be better for mango fruits to enhance shelf life and maintain the quality of fruits.

***Key words*:** Mango, Edible coating, Honey bee wax, Shelf life, Quality

Mango (*Mangifera indica*) is a valuable tropical fruit crop with high market potential. Mango fruits are rich in nutrients, minerals, carbohydrates, proteins, and lipids, including vitamins A (beta carotene), B_1, B_2, and C (ascorbic acid), and they have a great flavor and aroma [1]. also rich in bioactive components, which make them a fantastic source of antioxidants that can delay the aging process, enhance lung function, and lessen the difficulties associated with diabetes, in addition to lowering the risk of some types of cancer [2]. After being harvested, mango fruits ripen quickly, usually within 3 to 9 days. Long-distance commercial shipment of this fruit is severely restricted by the short time [3]. Fruit may only be stored and transported to a limited extent due to its sensitivity to decay, low temperature tolerance, and general perishability from quick ripening and softening. Mangos are climacteric fruits that mature quickly after being harvested. This restricts their ability to be handled, stored, and transported. A fruit undergoes an array of color, flavor, and texture changes as it ripens, all of which point to compositional alterations. Achieving the highest possible standard of eating appears to require such a shift. The quality, rate of deterioration, and shelf life of fruits are determined by the aforementioned changes and their rapidity. After harvesting, production and consumption imbalances and the fruits' easy access to postharvest disease infection cause significant losses. Consequently, interventions that slow down the rate at which ripe mangoes ripen during distribution and promote a supply of high-quality ripe fruits could aid in the expansion of mango markets. Therefore, in order to reduce post-harvest losses and increase shelf life while maintaining quality at a reasonable cost, alternative, appropriate post-harvest methods must be found. The development of edible coatings is currently attracting attention since these technologies ought to be straightforward, widely accessible, ecologically benign, and reasonable with no known negative impacts on human health. At present, consumers are interested in safe and biodegradable edible films or coatings derived from natural bio-based products.

Edible coating has proven to be an effective moisture barrier, halting the evaporation of water. Additionally, it improved the fruits' overall look. Fruit firmness, gloss, texture, and resistance to mechanical damage were all enhanced. This edible covering served as a decent gas barrier and, presumably, prevented some of the vitamin C from being deactivated [4]. The fruit's surface is covered in a thin layer of natural layers

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created by the edible covering. It does, in fact, act as a barrier against microbial contamination, moisture loss, preservation of textural qualities, preservation of color and volatile flavor chemicals, and slowing down the rate of respiration and transpiration of fruits [5]. The use of beeswax coating showed a beneficial influence on quality maintenance in mango [6] and sweet orange [7], even in ambient settings. The edible covering made of beeswax and coconut oil turned out to be a highly effective method for processing strawberries and apricot fruits as little as possible [8]. Extracts from aloe vera decreased the diffusion and transmission of water. Moreover, fruits' physicochemical properties such as weight loss, hardness, pH, and TSS contents were considerably preserved by coverings with varying concentrations of bee wax. According to Amin *et al*. [9], coating also decreased oxygen permeability, which lessened the oxidation of phenolic components in coated fruits.

Using aloe vera gel as a covering can extend the shelf life of mango fruits after harvest while preserving their quality, which lowers postharvest losses. The findings demonstrated that at both temperatures, concentrations of 50 and 75% aloe considerably extended the evidence of shelf life by reducing the decline in titratable acidity. In these treatments, fruit color and ascorbic acid were likewise preserved for 20 days [10]. The shelf life of edible-coated guavas increased by nine days. It indicates the ability of the biodegradable coating to reduce mass loss during storage time. Furthermore, even after 27 days of storage, the fruit had not yet attained senescence, demonstrating how efficient the coating was in slowing down the ripening process [11]. The guavas were coated with cassava starch and bee wax, which helped to preserve the fruits' quality for an extended period of time by postponing mass and chlorophyll loss and preserving their high-quality levels [12]. According to Neeta *et al.* [13], these findings suggest that using 5% zein and 10% gelatin could be a good substitute for preserving the mango fruit's qualitative qualities and increasing its shelf life while it is being stored.

MATERIALS AND METHODS

The investigation on different edible coatings on shelf life and quality of mango (*Mangifera indica*) was carried out in the pomology laboratory, Department of Horticulture, Adhiparasakthi Horticultural College, Tamil Nadu, during 2022. The details of the materials used and the methods adopted during the course of the investigation are presented below. Mango was obtained from the orchard, Department of Horticulture, Faculty of Horticulture, Adhiparasakthi Horticultural College. Honey Bee Wax was obtained from the Kevin Apiary, Coimbatore district, Tamil Nadu. Aloe vera gel was obtained from the nursery, Department of Horticulture, Adhiparasakthi Horticultural College. Gelatin was obtained from the grocery shop in Kalavai, Ranipet. The treatments consist of T_1-Honey Bee Wax 10%, T_2-Honey Bee Wax 25%, T_3-Honey Bee Wax 30%, T_4-Aloe Vera Gel 10%, T_5-Aloe Vera Gel 25%, T_6-Aloe Vera Gel 30%, T_7-Gelatin 10%, T_8-Gelatin 25%, T_9-Gelatin 30%, and T_{10}-Control. Treatments were applied as post-harvest dips. The fruits were dipped for 5 minutes in honey bee wax (10%, 25%, 30%), aloe vera gel (10%, 25%, 30%), and gelatin (10%, 25%, 30%). The fruits were air-dried for 30 minutes after each treatment. Detailed observations were periodically recorded on the 3rd, 6th, and 9th days of storage for all the parameters. The data were statistically analyzed using the analysis of variance technique for a complete randomized design, as described by Panse and Sukhatme [14]. Each case's proper standard errors of means (S.Em (+)) were determined, and the critical difference (C.D.) at the percent level of probability was computed to compare the two treatment means in cases where the treatment effects were statistically significant.

Organoleptic test

A group of judges evaluated the fruits' flavors and tastes. As listed under mango were the marks assigned to the various grades.

Details	Scale
Like extremely	9-10
like very much	8-9
Like moderately	7-8
Like slightly	6-7
Neither like nor dislike	5-6
Dislike slightly	4-5
Dislike moderately	3-4
Dislike very much	2-3
Dislike extremely	1-2

RESULTS AND DISCUSSION

Physiological loss in weight

The data pertaining to physiological loss in weight at the 3rd, 6th and 9th days after storage are presented in (Table 1). The fruits treated with honey bee wax 25% significantly recorded the lowest physiological loss in weight of 0.19, 0.25, and 0.33% at the 3rd, 6th, and 9th days after storage, respectively, and the control recorded the maximum physiological loss in weight of 5.13, 10.72, and 16.42%, respectively, at the 3rd, 6th, and 9th days after storage. The reduced physiological loss in honey bee wax may be a result of respiration being inhibited by honey bee wax, altering the membrane's permeability [15]. According to Shahid and Abbasim [16], the beeswax coats extended the shelf life of sweet oranges by lowering the respiration rate of the fruits. Fruit dehydration causes a physiological loss of weight due to changes in the fruit's resistance to water vapor transfer on its surface, respiration rate, and the formation of microscopic fissures connecting its internal and external atmospheres. Honey bee wax could reduce endogenous substrate catabolism during respiration and keep it out of reactions associated with internal breakdown in apples by inhibiting the diffusion of substrate from the vacuole to the cytoplasm and promoting the uptake of sorbitol. Beeswax has been reported in several studies to be used as a fruit coating agent for tangerine oranges [17], plums [18], oranges [19], mangoes [20], and apricots [21]. The application of beeswax to enhance the quality of lime has also been reported by Kumpoun and Uthaibutra, [22] and Nasrin *et al*. [23].

Total soluble solids

The data on total soluble solids as influenced by various edible coating treatments recorded at 3rd, 6th and 9th days after storage are presented in (Table 1). The maximum TSS values (9.00, 10.20, and 11.35) at 3rd, 6th and 9th days of storage recorded in T_2 (honey bee wax 25%) and untreated fruits recorded less TSS of 3.05, 3.15, and 4.19 brix at the 3rd, 6th and 9th days, respectively. Carrillo-Lopez *et al.* [24] observed a similar thing, reporting that total soluble solids in both coated and untreated "Haden" mangoes increased during the course of storage and peaked after 16–24 days. According to Bassetto *et al*. [25], the fruit's sugar content frequently increases as it ripens because of biosynthetic processes or the breakdown of polysaccharides.

Spoilage loss

The mean data on spoilage loss (%) as influenced by various edible coating treatments recorded at the 3rd, 6th, and 9th days after storage are presented in (Table 1). The treatment (T_2) honey bee wax 25% significantly recorded the lowest spoilage loss, i.e., 0.45 and 0.69%, respectively, at the 6th and 9th days after storage. Treatment (T_{10}) control recorded maximum spoilage loss, i.e., 9.25 and 12.39% at the 6th and 9th days after storage, respectively. Honey Bee Wax may have a delayed senescence impact by maintaining synthesis and slowing down respiration, hence increasing the firmness of fruit tissues and reducing fruit spoilage [26]. The reduced spoilage loss in the honey bee wax treatment is likely due to its ability to delay senescence by maintaining metabolic processes and reducing respiration rates. Honey bee wax also inhibits cellular disintegration [27-29].

Table 1 Effect of edible coatings on shelf life and quality of Mango (*Mangifera indica*)

Treatments	Physiological loss in weight (%)			TSS (Brix)			Spoilage loss (%)		Days to shriveling initiation	Fruit color	Shelf life (Days)
	3rd day	6rd day	9th day	3th day	6th day	9th day	6th day	9th day	9th day	9th day	-
T_1	0.21	0.35	0.93	9.07	10.56	13.35	0.75	1.18	7.50	8.53	12.56
T_2	0.19	0.25	0.33	9.29	10.88	14.14	0.45	0.69	10.50	9.06	16.35
T_3	0.27	0.46	1.00	9.00	10.20	12.35	0.90	2.50	8.50	7.22	11.25
T_4	4.59	8.74	15.28	9.27	10.78	14.42	8.00	9.75	6.75	6.72	10.89
T_5	4.17	7.46	13.35	9.02	10.33	12.44	5.75	9.00	7.25	7.15	11.20
T_6	4.59	7.71	14.28	9.25	10.76	13.70	4.50	8.00	7.50	8.77	12.76
T_7	4.11	7.23	12.89	5.15	6.25	7.39	1.44	3.73	4.57	3.17	7.01
T_8	4.18	7.80	13.42	3.17	4.46	4.57	3.79	5.23	5.82	4.20	8.28
T_9	2.11	3.83	4.75	4.29	4.84	5.80	4.25	5.39	6.63	3.78	8.05
T_{10}	5.13	10.72	16.42	3.05	3.15	4.19	9.25	12.39	4.27	2.07	6.56
S.Ed.	0.09	0.32	0.37	0.15	0.15	0.33	0.98	1.05	0.82	0.09	1.20
CD (P=0.05)	0.27	0.97	1.10	0.34	0.46	1.00	1.24	2.27	1.63	0.27	2.51

T_1:	Honey Bee Wax 10%	T_6:	Aloe Vera Gel 30%
T_2:	Honey Bee Wax 25%	T_7:	Gelatin 10%
T_3:	Honey Bee Wax 30%	T_8:	Gelatin 25%
T_4:	Aloe Vera Gel 10%	T_9:	Gelatin 30%
T_5:	Aloe Vera Gel 25%	T_{10}:	Control

Days to shriveling initiation

Edible coating treatments were recorded at 3rd, 6th, and 9th after storage, as presented in (Table 1). The treatment (T_2) Honey Bee Wax 25% recorded the late initiation of shriveling, i.e., 10.50 days after storage, as compared to the rest of the treatments. An early shriveling was recorded in the fruits of treatment (T_{10}) at 4.27 days after storage. This could be because the cell wall has more contributing strength. Regardless of the amount of honey bee wax present in the tissue cell wall in vivo, a significantly higher concentration may have added strength, allowing for a delay in the cell wall's breakdown and subsequent increase in permeability. The overall effect of such an intermediary-modified cell wall structural feature may alter the morphological characteristics of the entire mango fruit [30].

Fruit colour

After the organoleptic test, the fruit color at 9th day after storage was recorded and is presented in (Table 1). The treatment (T_2) Honey Bee Wax 25% significantly recorded the most attractive fruit color and found the maximum value of fruit color, i.e., 9.06, at the 9th day after storage, and the minimum was recorded in the control (2.07). Fruit colour changes during storage are associated with the production of pigments like carotenoids. Given that the beeswax coating affected the fruit's internal gas composition and delayed the diffusion of gases, it was plausible that the delayed colour changes in the coated fruits were caused by a decrease in the activity of enzymes involved in the synthesis of carotenoids. However, the reduced colour loss in the coated fruit may have been explained by the beeswax coating's capacity to postpone the synthesis of carotenoids [31]. In a similar vein, Mladenoska [32] and Nasrin *et al.* [33] noted that the appearance of strawberry and lemon fruits was enhanced by beeswax coatings containing coconut oil. The beeswax coating may act as a barrier to prevent the diffusion of oxygen and carbon dioxide, which could lead to a decrease in respiration and other metabolic processes that could alter the color of the material.

Shelf-life

The treatment (T_2) Honey Bee Wax 25% recorded a significantly maximum shelf life (16.35 days), but the treatment (T_{10}) control recorded a minimum of 6.56 days. The current findings corroborated those of Penchaiya *et al*. [34] applying an edible covering increased the shelf life of mango fruits.

CONCLUSION

The findings indicate that mango fruits treated with 25% honey bee wax had lower physiological weight loss, minimal TSS content, delayed shrivelling initiation, and reduced spoilage loss. The highest organoleptic scores were recorded for fruit treated with honey bee wax on the third, sixth, and ninth days of storage, which included colour, pulp colour, taste, and aroma. The promise of beeswax as an edible fruit coating substance is supported by these findings. Additionally, compared to the expensive cost of commercial coating chemicals, utilizing beeswax may have economic benefits, particularly in underdeveloped nations. Therefore, if fresh mangoes are handled carefully with the right kind of wax coat and concentration, mango supervisors can readily adapt the technology to treat fresh mangoes in order to transport them over great distances without compromising their quality.

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