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Dracaena cinnabari Resin and Chitosan Coating to Increase Shelf-Life of Tomato

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ABSTRACT

Attempts have been made to increase the shelf life of tomatoes by incorporating antimicrobial agent i.e. resin of *D. cinnabari* in chitosan-based coating solution. In the present study shelf life of tomatoes was improved by (a) optimizing the concentration of chitosan for coating base material (b) optimizing the concentration of antimicrobial agent i.e. *D. cinnabari*. Three different concentrations (0.5, 1.0, and 1.5%) of chitosan were tested. Among them, 1% chitosan was most effective in terms of retention of fruit quality (lower shrinkage, overall acceptability). *In vitro* activity of antimicrobial agent i.e. *D. cinnabari*(1, 2, 3, 4, 5, and 12.5 mg) was checked against fruit rotting microorganisms. Incorporation of the antimicrobial agent in the coating solution resulted in the retention of physicochemical characteristics (moisture, pH, titrable acidity, total soluble solids, lycopene content, and antioxidant activity). The outcome of the present study demonstrates the feasibility of applying the edible coating to increase the shelf life of tomatoes up to 25 days at room (30±2°C) and low (10±2°C) temperature conditions.

INTRODUCTION

Fresh vegetables are highly perishable and susceptible to postharvest spoilage which limits the storage period and marketing life and causes economic losses [1]. To overcome loss physical and chemical technologies have been tested. Among these, an edible coating is acceptable because it consists of natural, biodegradable, substances [2, 3]. Consumers demand high-quality food without chemical preservatives and with an extended shelf-life.

Tomato (*Solanum lycopersicum* L) a perishable vegetable and postharvest decay results in high economic loss. Decay due to bacteria and fungi are common causes of postharvest losses[4, 5]. Fungal diseases are more severe than bacterial diseases because fungi are generally more difficult to eradicate [6]. Other than microbial deterioration environmental factors of soil type, temperature, and rainy weather cause decay of tomatoes during storage [7].

Cold storage, modified and controlled atmosphere, and edible coating have been developed to prevent post-harvest loss in tomatoes [8, 9]. Edible coatings are thin layers of edible material that can be consumed, coated on a portion of food, or placed as a barrier to moisture and oxygen between the food and the surrounding environment during processing, handling, and storage. An edible coating retards food deterioration but enhances safety due to their natural biocide activity, or by the inclusion of antimicrobial compounds [10]. These antimicrobial compounds can be extracted from and plant sources. *Dracaena cinnabari* (Ministry of Ayush) is a plant with antimicrobial activity [11].

To the best of our knowledge use of *D. cinnabari* as an antimicrobial agent in an edible coating solution has not yet been reported. This study was undertaken to determine the efficacy of *D. cinnabari* to increase shelf-life of tomato by as an antimicrobial edible coating. Specific objectives were to select potential solvent for extraction of antimicrobial factors from *D. cinnabari*, optimize chitosan and antimicrobial extract concentration for coatings, study effects of edible coating on physicochemical properties of tomato.

MATERIALS AND METHODS

Microbial pathogens and culture conditions

The test fungi *Penicillium* sp. NFCCI 2849, *Rhizopusstolonifer* NFCCI 2853, and *Aspergillusniger* MTCC 281 were grown on potato dextrose agar (PDA) (M096, Hi-Media, India) and incubated at 30°C for 7 days, then stored at 4°C for further use. The bacteria *Bacillus cereus* MTCC 6629, *Staphylococcus aureus* MTCC 9542, *Escherichia coli* MTCC 739, and *Salmonella enterica* MTCC 3219 were grown on nutrient agar (NA) (M001, Hi-Media, India) at 37ºC for 24 h and then stored at 4ºC. The fungal cultures were identified by the National Fungal Culture Collection of India, Agharkar Research Institute, Pune, India and Microbial Type Culture Collection and Gene Bank (MTCC) and microbial strains obtained from MTCC, Institute of Microbial Technology, Chandigarh, India.

Preparation of *D. cinnabari* resin extract as an antimicrobial agent

The *D.cinnabari* resin was obtained from the Ministry of Ayurveda, Yoga, and Naturopathy, Unani, Siddha and Homoeopathy, Ministry of Health, Govt. of India, New Delhi. Powdered resin (25 g) was sequentially extracted with 250 mL of petroleum ether (PE), dichloromethane (DCM), or methanol (Me-OH) by shaking overnight at 180 rpm and 30°C on an orbital shaker. All organic phases were collected and filtered through Whatman No. 1 filter paper under gravity and evaporated to dryness on a rotary evaporator under vacuum at not more than 40°C. All crude extracts were dissolved in dimethylsulfoxide (DMSO) and assayed for anti-microbial activity.

In-vitro antagonism of organic extracts

To estimate the potential of organic phase extracts for extraction of antimicrobial agent, the activity of the solvent extracts (PE, DCM, and Me-OH) was performed against *B. cereus* MTCC 6629, *S. aureus* MTCC 9542, *E. coli* MTCC 739 and *S. enterica* MTCC 3219 using an agar well diffusion method to evaluate antibacterial activity. Nutrient agar plates were seeded with cells of the test bacteria (50 µL) and an 8.0 mm hole was punched in the center of the plate with a sterile cork borer. One-hundred µL of each solvent extract, equivalent to 1 mg, was added to wells separately, DMSO alone was the control. All agar plates were incubated at 37°C for 24 h and zones of inhibition measured using the Hi-media zone reader scale. All the experiments were performed in triplicates.

Fungal mycelial growth inhibition activity of all organic phase extracts was estimated using a "cross plug" assay against 7 days old culture of *Penicillium* sp. NFCCI 2849, *R. stolonifera* NFCCI 2853, and *A. niger* MTCC 281. Eight-mm diameter holes were cut with a cork borer in centers of each PDA plate 100 µL of each organic phase extract, equivalent to 1 mg, was pipetted into the wells. Fungal agar plugs (8.0 mm dia) were transferred onto the periphery of each plate at both sides. The clear-zone diameter around the wells was measured after 14 days of incubation using the Hi-media zone reader scale. All the experiments were performed in triplicates.

Standardization of DCM extracts concentration

The DCM extract of *D. cinnabaris* xhibited strong antimicrobial activity against the growth of tested microorganisms; it was selected as an antimicrobial agent that can be incorporated into chitosan coating. Concentrations of DCM extract of 1, 2, 3, 4, 5 mg in 100 µL extract were screened for anti-microbial potential and compared to the control DMSO. All the experiments were performed in triplicates.

Preparation of chitosan solution

Chitosan aqueous solution was prepared according to the method [12] with slight modification. Chitosan powder (C3646, Sigma, Delhi, India) at 0.5, 1 or 1.5% were dissolved in 0.5% (v/v) glacial acetic acid. For complete dispersion of chitosan, the solution was stirred overnight at 30^{o}C and filtered under gravity using cheese cloth to remove foams and other impurities. After filtration, 0.1% (v/v) glycerol was added as a plasticizer and 0.1% (v/v) tween-80 was added to improve wettability. The final volume of the solution was adjusted with distilled water. The final pH of the solution was adjusted to 5.6 with 1N NaOH as at this pH, chitosan (pKa = 6.2) is positively charged and exhibits maximal biological activity [13].

Standardization of chitosan concentration as a base coating

To determine the effective optimal concentration of chitosan solution, tomatoes were coated with 0.5, 1.0, or 1.5% of chitosan solution and compared to uncoated tomatoes as the control and stored at 30±2°C for 25 days (sample size = 50). Tomatoes were visually analyzed periodically at a 5-day interval for shrinkage and microbial spoilage. The latter was determined as decay percent [14]. Tomatoes showing symptoms of the disease and/or signs of the organisms were considered decayed.

Preparation and antimicrobial activity of *D. Cinnabari* containing chitosan coating solution

Autoclaved chitosan (1%) was homogeneously mixed with syringe filter-sterilized DCM extract (5 mg·mL^{-1}) under aseptic condition. Antimicrobial activity of coating solution was determined by agar well diffusion assay [15] against *A. niger* MTCC 281, *Penicillium* sp. NFCCI 2849 and *R. stolonifer*NFCCI2853.

***In-vivo* application of coating solution**

Fresh cherry tomatoes of medium size were procured from the local market of Dwarka, New Delhi, India, and classified based on size, weight, maturity stage, and presence of visual defects or injuries. The fruit was washed with running tap water for 2 min and immersed into 0.1% sodium hypochlorite solution for 1 min followed by aseptically rinsing in sterile distilled water for 5 min and then air-dried for 1 h in a biosafety cabinet. The coating was applied by immersion of tomatoes in 1% chitosan solution containing DCM extract of *D. cinnabari* resin (5 mg·mL^{-1}) for 1 min; control fruit was coated with 1% chitosan solution and an aqueous solution of glacial acetic acid [1%, (v/v)] separately, to determine effect of chitosan and acidic pH on growth of microorganisms [16]. After dipping, the residual solution was allowed to drain off the tomatoes which were then air-dried under biosafety for 2-3 h. Tomatoes were then placed into trays and incubated at 30±2ºC and 10ºC for 15 days. Experiments were conducted twice.

Tomatoes were classified according to the ripening stage using a visual scale [17]. Fruit decay was visually inspected during storage. Coated and un-coated tomatoes were investigated for weight loss percent, pH, titrable acidity (TA**)**, total soluble solids (TSS), lycopene content, and antioxidant activity periodically.

Physico-chemical analysis

% Weight loss

To determine weight loss 7 tomatoes from each treatment were weighed just after coating and air-drying. Weight loss percent was calculated with an established method (AOAC, 2000).

pH

The pH of the tissue was determined after the fruit was cut into pieces and homogenized and then filtered under gravity through a muslin cloth. Change in pH was monitored with a digital pH meter (Orion 2 Star pH benchtop, Thermo Scientific, Delhi**,** India).

Titrable acidity (TA)

The Titrable acidity (TA) of tomato juice was determined [18].

Total soluble solids (TSS)

Total soluble solids of tomato juice were determined by using a digital refractometer (A. krüssoptronic, Hamburg**,** Germany).

Free radical scavenging activity

The2,2-diphenyl-1-picrylhydrazyl (DPPH) free radical scavenging assay was performed to check the antioxidant capacity of tomato juice as per the method [19].

Lycopene content

Lycopene content of tomato juice was determined [1].

Statistical analysis

The data were subjected to analysis of variance in SPS (ver. 11.5, SPSS Inc., Chicago, IL). If interactions were significant they were used to explain results. If interactions were not significant means were separated using Duncan's, LSD test.

RESULTS AND DISCUSSION:

In vitro antagonism of D. cinnabari resin extracts

D. cinnabari resin was extracted with different organic solvents with increasing polarities to isolate a broad-spectrum antimicrobial agent. Twenty-five grams of powdered resin was sequentially extracted with 250 ml of petroleum ether (PE), dichloromethane (DCM) and methanol (Me-OH), and all the organic extracts were concentrated to dryness and gave a yield of 4.8, 10.88 and 21.36 %, respectively. All the organic extracts were re-dissolved in

DMSO separately and checked for their antimicrobial potential. Among them maximum zone of inhibition was shown by DCM extract, followed by Me-OH extract whereas no anti-microbial activity was shown by the PE extract against tested microorganisms (**Figure 1**). Experiment was conducted in triplicates. Henceforth DCM was found to be the best solvent for the extraction of maximum antimicrobial metabolite(s). These results are in accordance with[11].

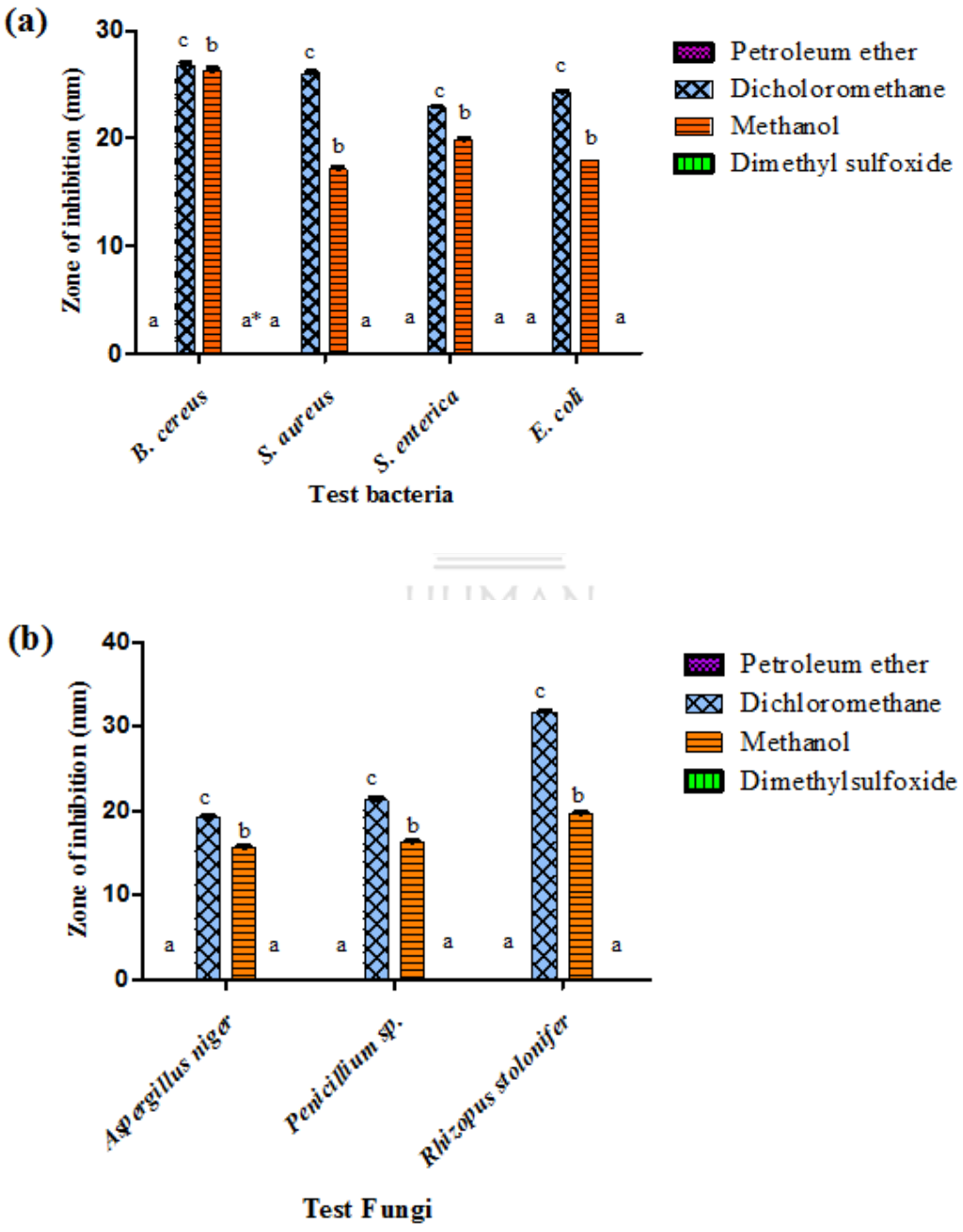

Figure No. 1: *In-vitro* antagonism of organic solvent extracts against bacteria (a) and fungi (b).

*Different lower case superscripts on the bar diagram indicate the significant difference (P<0.05). The experiment was performed in triplicates.

Determination of effective concentration of DCM extract

Different concentrations (1, 2, 3, 4, 5 mg/100 µl) of DCM extract were screened against various microorganisms (*B. cereus* MTCC 6629, *S. aureus* MTCC 9542, *E. coli* MTCC 739 *S. enterica* MTCC 3219, *Penicillium* sp. NFCCI 2849, *R. stolonifera* NFCCI 2853 and *A. niger* MTCC 281). With increasing DCM extract concentration (1-5 mg per 100µl), a diameter of zone of inhibition also increased (**Table 1**) however this increase was not effective as concentration got double. Therefore, 5 mg/100µl was considered for further *in-vivo* studies.

Table No. 1: *In-vitro* activity of different concentration of DCM extract against fruit rotting microorganisms

	Antimicrobial activity [Zone of Inhibition (mm)]					
	Dichloromethane extract conc. (mg/ml)					
Test microbes	1	2	3	4	5	12.5
Bacteria						
B. cereus	19.6±0.15^{c}	21.16±0.25^{b}	21.06±0.20^{b}	21.10±0.26^{b}	21.00±0.10^{b}	22.30±0.30^{a}
S. aureus	16.7±0.26^{d}	18.00±0.36^{c}	18.16±0.32^{c}	19.10±0.21^{b}	19.16±0.25^{b}	19.80±0.15^{a}
E. coli	15.7±0.20^{c}	18.03±0.25^{b}	18.20±0.26^{b}	18.36±0.05^{b}	18.06±0.20^{b}	19.86±0.25^{a}
S. enterica	14.9±0.25^{c}	20.10±0.30^{b}	20.13±0.25^{b}	20.23±0.15^{b}	20.20±0.20^{b}	22.06±0.20^{a}
Fungi						
A. niger	11.9±0.15^{e}	14.00±0.36^{d}	26.03±0.32^{c}	27.10±0.25^{b}	28.40±0.30^{a}	28.03±0.15^{a}
***Penicillium* sp.**	0.00±0.00^{f}	17.80±0.35^{e}	19.06±0.37^{d}	22.00±0.26^{c}	28.13±0.21^{b}	29.63±0.40^{a}
R. stolonifer	16.8±0.35^{f}	22.20±0.26^{e}	26.23±0.30^{d}	28.40±0.10^{c}	30.26±0.30^{b}	31.66±0.41^{a}

In-vitro activity of different concentrations of DCM extract of D. cinnabari was performed against various microorganisms. The results are means of three replicates for each microorganism; Rating: Strong inhibition ≥ 25 mm; Moderate inhibition ≥15 mm; Weak inhibition ≤ 10 mm; One-way analysis of variance (ANOVA) was performed by Duncan's multiple range test using SPSS. Mean values were considered statistically significant (P<0.05) Mean values with different superscripts in the same row differ significantly (Duncan's, LSD test, P<0.05).

Optimization of chitosan concentration for tomatoes coating

Different concentrations (0.5, 1.0 and 1.5%) of chitosan solution were coated on tomato fruits and monitored for 25 days. After every 5 days of incubation, coated and non-coated tomatoes were monitored for shrinkage and microbial spoilage. Fruits coated with 1% chitosan delayed the ripening process by slowing down the respiration rate as compared to 0.5% coated fruits while in 1.5% coated fruits anaerobic respiration was observed due to thick coating.

Structural changes (Shrinkage)

The loss of moisture from fruits leads to structural changes in fruits. There was no visual shrinkage in the coated and control samples until 5 days of storage (**Figure 2**). After 5 days of storage at room temperature, (30±2°C) fruits coated with the 1.5% chitosan started shrinking due to anaerobic respiration whereas fruits coated with 0.5% and 1% chitosan were in good condition up to 15 days of storage. After 15 days of incubation, fruits coated with 0.5% chitosan also started shrinking due to water loss, whereas fruits coated with 1% chitosan coating stayed in better condition up to 25 days of storage.

Figure No. 2: Effect of different chitosan concentrations on tomatoes after 25 days of storage at room temperature (a)-Tomatoes treated with 0.5% chitosan, (b) - Tomatoes treated with 1% chitosan, (c)- Tomatoes treated with 1.5% chitosan and (d) - Control

Microbial spoilage or Decay percentage

Microbial spoilage of coated (0.5, 1, and 1.5%) and uncoated fruits were visually inspected after 5 days during the storage of 25 days. There were no visible symptoms of microbial decay in coated or control fruit until 5 days of the storage period. After that the coating (0.5%, 1%) significantly (P≤ 0.05) (**Table 2**) reduced decay compared to control fruit and fruits coated with 1.5% chitosan. The decay percentage was higher in the 1.5% coating solution due to anaerobic respiration of fruit. Fruits coated with 1% chitosan coating remained disease-free even after 25 days of storage at room temperature (30±2°C). The decrease in decay percentage can be related to the antimicrobial effect of chitosan and delaying senescence by creating a barrier between the fruit and outer environment.

Table No. 2: **Effect of different concentration of Chitosan on tomato fruit decay (%) during storage**

Treatments	**Time of storage (days)**					
	0	**5**	**10**	**15**	**20**	**25**
Control	0.00^{a}	0.00^{a}	8.00 ± 0.8^{b}	25.04 ± 0.9^{b}	49.08 ± 0.7^{b}	85.18 ± 0.8^{b}
0.5% Chitosan	0.00^{a}	0.00^{a}	0.00^{c}	4.36 ± 0.6^{c}	11.00 ± 0.3^{c}	21.00 ± 0.2^{c}
1% Chitosan	0.00^{a}	0.00^{a}	0.00^{c}	0.00^{d}	0.00^{d}	5.4 ± 0.5^{d}
1.5% Chitosan	0.00^{a}	0.00^{a}	10.65 ± 0.6^{a}	28.59 ± 1^{a}	52.23 ± 0.4^{a}	92.00 ± 1.2^{a}

Values in a column not followed by the same letter are significantly different (P≤0.05) acc to the LSD test. Storage condition (30±2°C). Sample size: 50 tomatoes for each treatment.

In-vitro activity of coating solution incorporated with an antimicrobial agent

To check the potential of coating solution incorporated with an antimicrobial agent to inhibit the growth of tested fungi, *in vitro* activity was checked. Reduced growth of fungi was observed in the plates incorporated with an antimicrobial agent with chitosan than control plates (**Figure3**). Therefore,5mg/100µlof*D.cinnabari*extractwasusedfor*invivo*experiments.

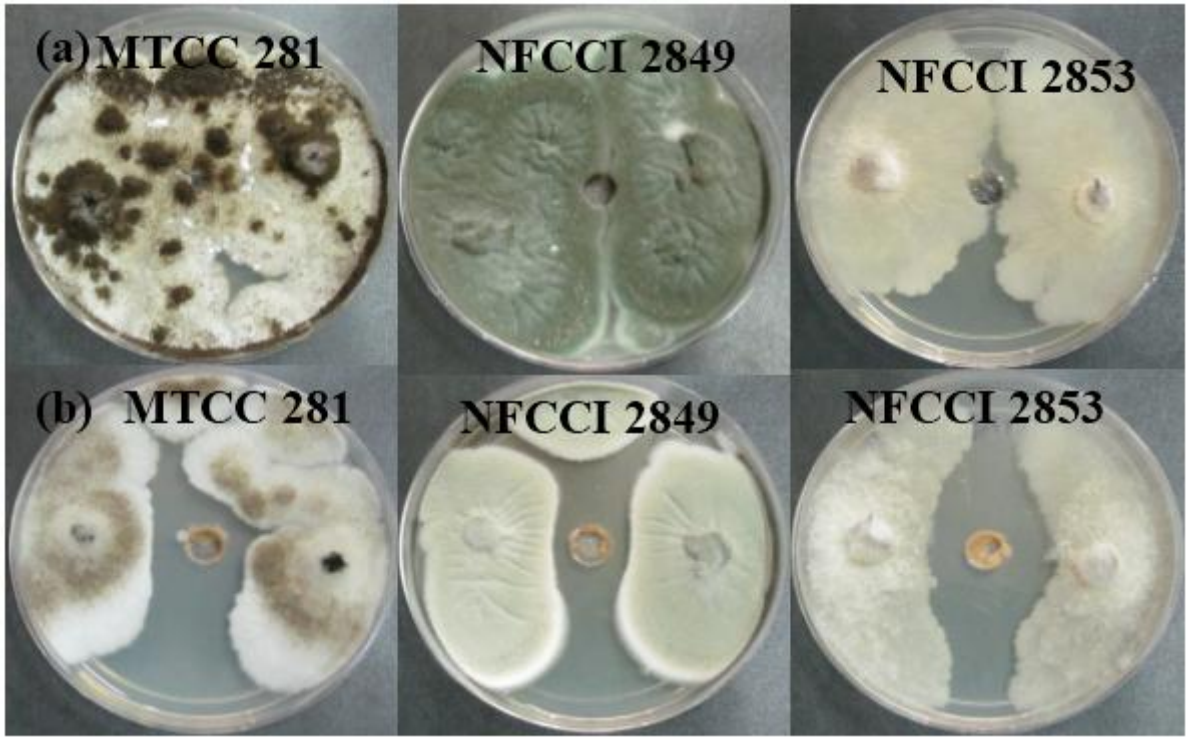

Figure No. 3: *In-vitro* antifungal activity of chitosan solution and DCM extract against *Aspergillusniger* MTCC 281, *Penicillium* sp. NFCCI 2849, and *Rhizopusstolonifer* NFCCI 2853(a): Control plates (b): Activity plate (Chitosan + DCM extract). The experiment was performed in triplicates.

In-vivo application of coating solution

Bioassays were performed under storage conditions to determine the effectiveness of a 1% chitosan solution containing 5 mg/100 µl DCM extract of *D. cinnabari* resin at 30°C and 10°C for 15 days.

Weight loss percentage

Fresh fruits and vegetables are highly susceptible to weight loss. Therefore, evaluating the weight loss percentage is very important for fruits and vegetables during storage. Results obtained in this study indicated that weight loss percentage increased gradually during the storage period (up to 15 days) at both temperature conditions (30±2°C, 10±2°C) (**Figure 4.1 a & 4.2 a**). However, less change in weight loss was observed at a lower temperature (10±2ºC) than room temperature (30±2°C) due to less evaporation of water at a lower temperature. The weight loss of all coated samples (with or without *D. cinnabari* extract) was comparatively lower than the uncoated samples. The addition of *D. cinnabari* resin extract in

the coating formulation could be responsible for lower weight loss in coated fruits (chitosan + *D. cinnabari* extract) as compared to chitosan-coated and uncoated samples. The main reason behind the weight loss is vapor pressure gradient and respiration which causes wilting and shriveling in the fruits and vegetables resulting in low market value and acceptability by the consumers [20]. Edible coating act as a barrier to water loss between the fruit and outer atmosphere by maintaining high relative humidity in the surrounding atmosphere of fruit and therefore, reduce the moisture gradient to the exterior [21]. Similar results were observed [20] for tomatoes coated with gum Arabic coating.

Change in pH

The effect of different edible coating solution (Chitosan+ extract, Chitosan) on tomatoes as compared to control samples at different temperature conditions is given in **Figure 4.1**a **& b.** These results indicated that the pH of tomato fruit increased during the storage period. Among all the treatments fruits coated with (Chitosan + extract) showed the least increase in pH (4.04±0.02 to 4.27±0.01 at room temperature and 4.2±0.02 to 4.43±0.017 at 10°C) after 15 days of storage. Similar results were observed [22] for strawberries coated with chitosan. pH is the equilibrium measure of hydrogen ion concentration in a juice. Organic acids provide most of the hydrogen ions in tomatoes which normally decrease with ripening, thereby producing an increase in pH [23]. pH of the tomato depends upon the acid content of the fruit and as the fruit moves towards the maturity, pH gets increased due to the loss of organic acids [24].

Change in titrable acidity (TA)

The effect of the application of coating solution on titrable acidity content of tomatoes is shown in **Figure 4.1 c & 4.2 c**. The titrable acidity decreased during the storage period (0-15 days) in all coated (Chitosan+extract, Chitosan) and control (uncoated) fruits. Results of the present study indicated that the application of coating solution delayed the rate of titrable acidity as compared to control fruit at both temperature condition (30±2° and 10±2° C). The titrable acidity in tomatoes is due to the presence of organic acids i.e. citric acid, malic acid, and glutamic acid [24]. Titrable acidity decreased with the storage period due to the loss of organic acid as these acids function as a primary substrate for the metabolic reaction [25]. Sometimes TA increases with the incubation period due to anaerobic respiration (elevation in CO_2 concentration and reduction in O_2 concentration). These can affect the glycolytic

enzyme system, resulting in a build-up of acids [26]. The present study revealed that the use of edible coating slowed down the respiration rate by providing a semi-permeable membrane around the fruit hence delayed the utilization of organic acid. A similar result for retention of TA with the coating was observed for tomatoes coated with gum Arabic [20].

Change in Total soluble solids (TSS)

The change in TSS of coated and uncoated samples during the incubation period is shown in **Figure 4.1 d & 4.2 d**. TSS increases with the storage period (0 to 15 days) due to water loss and solubilization of cell wall components [14]. In the present study, TSS content increased gradually in both coated as well as uncoated samples. Controltomatoes showed an increase of 16.28 percent in TSS by 15 days of storage while the coated samples of chitosan supplemented with extract and without extract showed an increase of 8.62 percent and 11.36 percent, respectively at room temperature (30±2°C). Slight changes were observed at low temperatures (10±2ºC) due to a lower respiration rate. Similar results for tomatoes coated with chitosan and zeolite coating were found [14].

Change in antioxidant activity

The total antioxidant capacity of tomatoes was determined by percent inhibition of DPPH. The result of the present study indicated that the maximum peak (percent inhibition of DPPH) reached 7 days of storage in the uncoated sample and then decreased sharply until the end of the storage period. However, in a coated sample (Chitosan + extract, Chitosan) maximum peak (percent inhibition of DPPH) was observed at 15 days of storage. The main antioxidants in tomatoes are carotenoids, ascorbic acid, and phenolic compounds. The total antioxidant activity is dependent upon the ripening process and increases with ripening due to the changes in lipophilic antioxidant activity. By applying the coating solution respiration rate can be slowed down and antioxidant activity can be maintained for a longer storage period [1]. The result for the same is given in **Figure 4.1 e & 4.2 e**.

Effect on lycopene content

Lycopene content increased with the storage period (0 to 15 days) in both coated and uncoated fruits. However, the lycopene content in the uncoated sample increased sharply as compared to coated fruits at both temperature conditions (30±2° C & 10±2°C). The result for the same is given in **Figure 4.1 f & 4.2 f.** On the other hand, there was a minimum increase

in lycopene content stored at a lower temperature (10±2°C) due to slower respiration rate as its production depends upon the temperature and respiration rate. Lycopene is a red-colored carotenoid pigment present in ripe tomatoes and its production increases with the ripening process. Similar results were observed [1] for tomatoes.

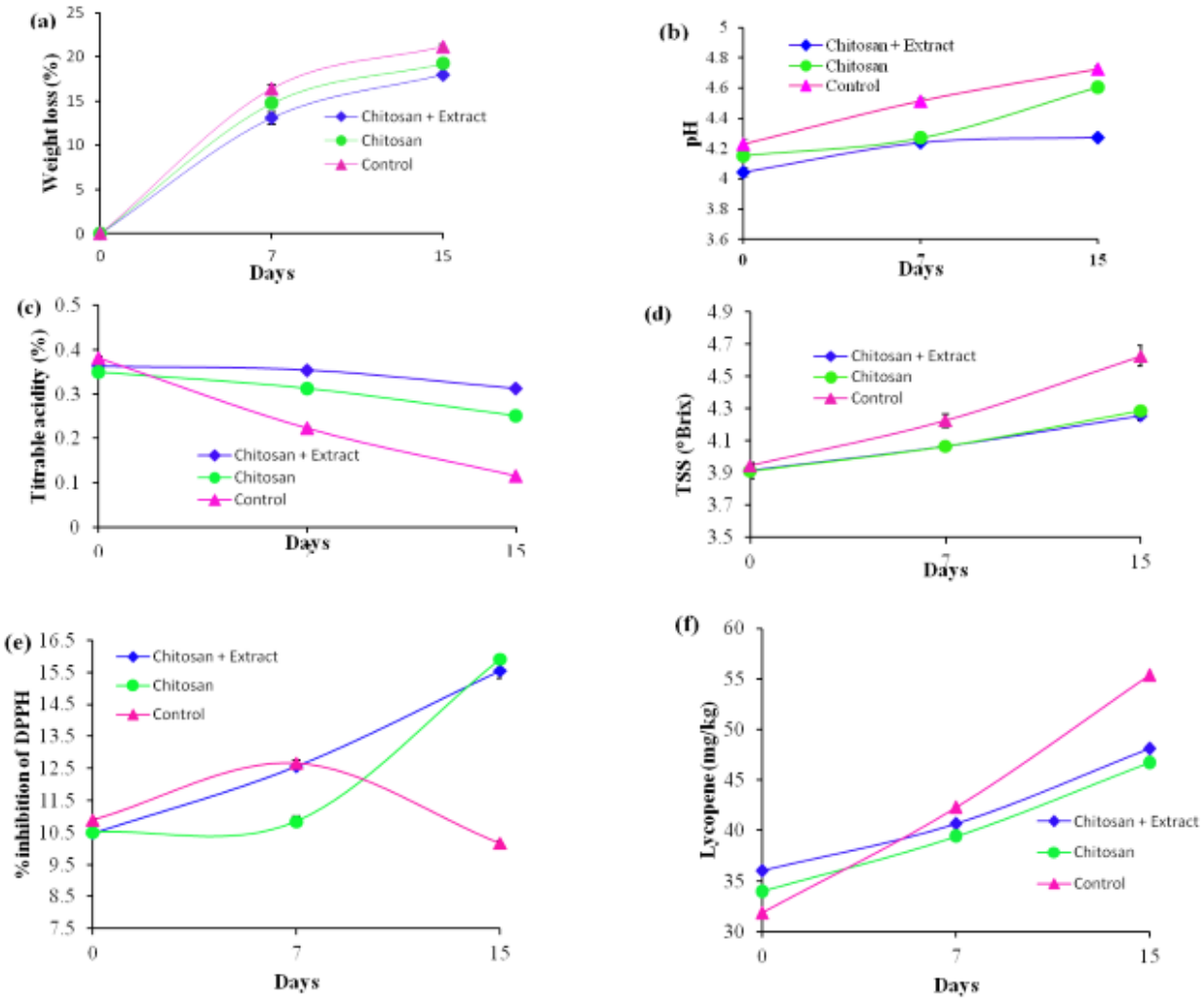

Figure No. 4.1: Effect of coating solution on the Physico-chemical properties of tomatoes stored at room temperature (30±2°C). Experiment was performed in triplicates.

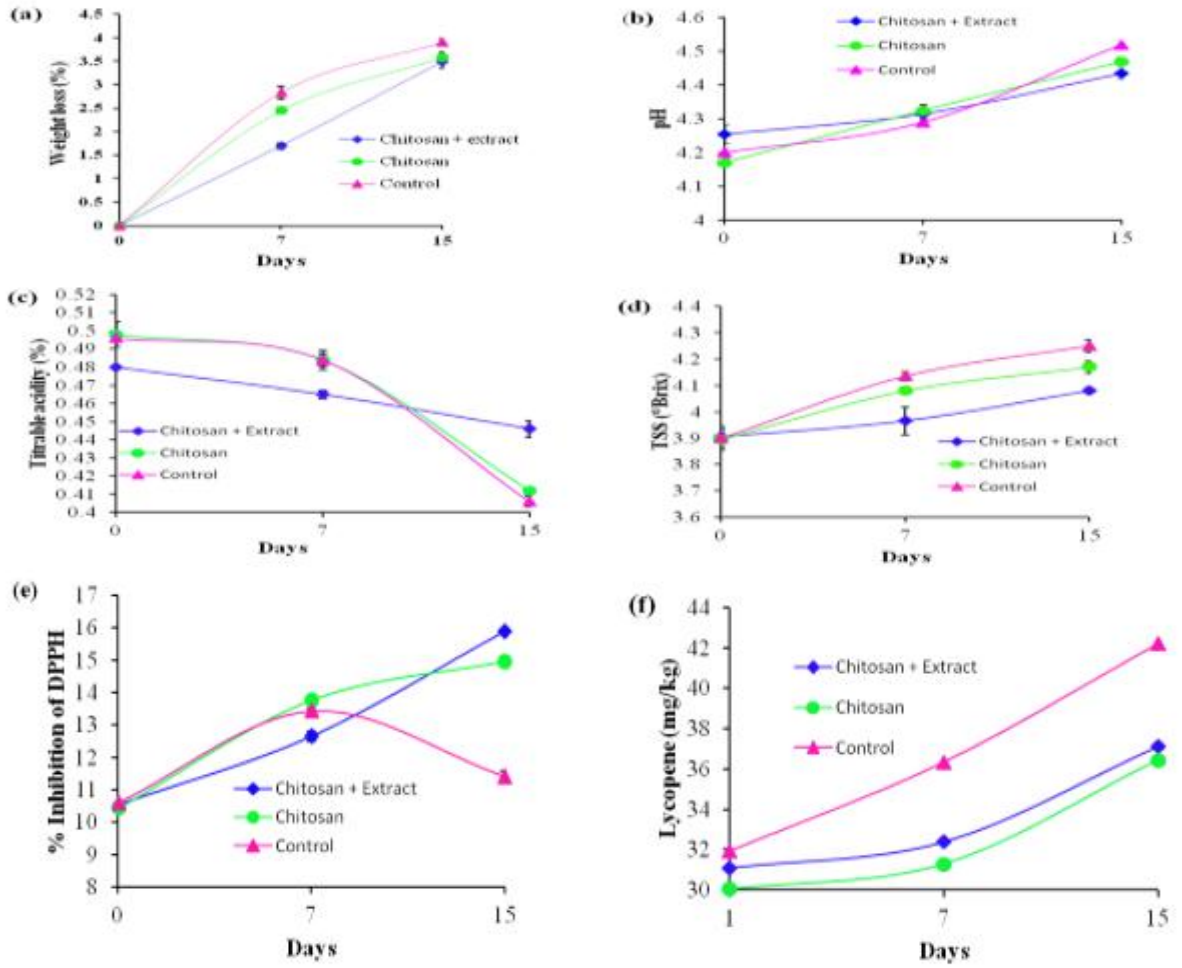

Figure No. 4.2: Effect of coating solution on the Physico-chemical properties of tomatoes stored at a lower temperature (10±2°C). Experiment was performed in triplicates.

CONCLUSIONS

This study reveals that the DCM extract of *D. cinnabari* resin has the potential to inhibit the tomatoes spoiling microbes. These results demonstrated the ability of the edible coating to act as a barrier between the internal atmosphere of the fruit and the outer environment. It was observed that coating done with 1per cent chitosan solution was more effective than 0.5 percent and 1.5 percent chitosan. Better results were obtained when the coating solution was mixed with antimicrobial extract as compared to the chitosan coating alone and control samples. Delayed changes in weight loss, TSS, TA, antioxidant activity, and lycopene content were observed in coated fruits as compared to the control sample. Delayed changes in physiological and chemical properties of tomatoes were observed at low temperature i.e. 10ºC than at room temperature.

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REFERENCES

[1] Ali A, Maqbool M, Alderson PG, et al. Effect of gum arabic as an edible coating on antioxidant capacity of tomato (*Solanum lycopersicum* L.) fruit during storage. Postharvest Biol Technol. 2013;76:119-124.
[2] Lin D and Zhao Y. Innovations in the development and application of edible coatings for fresh and minimally processed fruits and vegetables. Compr Rev Food Sci Food Saf. 2007;6(3):60-75.
[3] Debeaufort F, Quezada-Gallo JA, and Voilley A. Edible films and coatings: Tomorrow's packagings: A Review. Crit. Rev. Food Sci. Nutr. 2010;38(4):299-313.
[4] Kader AA. Effects of post harvest handling procedures on tomato quality. Acta Horti. 1986;190:209-221.
[5] Shenge KC, Mabagala RB, and Mortensen CN. Current status of bacterial-speck and spot diseases of tomato in three tomato-growing regions of Tanzania. Journal of. Agric. Ext. Rural Dev. 2010;2:84-88.
[6] Etebu E, Nwauzoma AB, and Bawol DDS. Postharvest spoilage of tomato (*Lycopersiconesculentum* Mill.) and control strategies in Nigeria. J BiolAgricHealthc. 2013;3(10):51-61.
[7] Matthew and Titus. Post-harvest microbial deterioration of Tomato (*Lycopersiconesculentum*) fruits. Report on an opinion. 2011;3(4):52-57.
[8] Ghaouth AE, Arul J, Ponnampalam R et al. Chitosan coating to extend the storage life of tomatoes. Hort Sci. 1992;27(9):1016-1018.
[9] Watada AE, Ko NP, and Minott DA. Factors affecting the quality of fresh-cut horticultural products. Postharvest Biol Technol. 1996;9(2):115-125.
[10] Cha DS and Chinnan M. Biopolymer-based antimicrobial packaging: A review. Crit. Rev. Food Sci. Nutr. 2004;44(4):223-237.
[11] Gupta D and Gupta RK. Bioprotective properties of Dragon's blood resin: *In vitro* evaluation of antioxidant activity and antimicrobial activity. BMC Complementary and Alternative Medicine. 2011;11:13.
[12] Ramos-Garcia M, Bosquez-Molina E, Hernandez-Romano J et al. Use of Chitosan-based edible coatings in combination with other natural compounds, to control *Rhizopusstolonifer* and *Escherichia coli*DH5α in fresh tomatoes. Crop Prot.2012;38:1-6.
[13] Poverenov E, Zaitsev Y, Arnon H et al. Effects of a composite chitosan–gelatin edible coating on postharvest quality and storability of red bell peppers. Postharvest Biol Technol. 2014;96:106-109.
[14] Garcia MA, Casariego A, Diaz R et al. Effect of edible chitosan/zeolite coating on tomato quality during refrigerated storage. Emir J Food Agric. 2014, 26(3):238-246.
[15] Sharma P, Choudhary B, NagpureAet al. Antifungal potential of actinomycete isolate *Streptomyces exfoliatus* MT9 against wood-rotting fungi. J Environ Biol. 2016;37:1231-1237.
[16] Ponce AG, Roura SI, Valle CE et al. Antimicrobial and antioxidant activities of edible coatings enriched with natural plant extracts: *In vitro* and *in vivo* studies. Postharvest Biol Technol. 2008;49(2):294-300.
[17] Wills RB, McGlasson B, Graham D et al. Postharvest: An introduction to the physiology and handling of fruit, vegetables, and ornamentals. University of New South Wales, Sydney, Australia; 2007.
[18] Ranganna S. Handbook of analysis and quality control for fruits and vegetable products. Tata McGraw Publishing Ltd., New Delhi; 2006.
[19] Alothman M, Bhat R, and Karim AA. Antioxidant capacity and phenolic content of selected tropical fruits from Malaysia, extracted with different solvents. Food Chem. 2009; 115(3):785-788.
[20] Ali A, Maqbool M, Ramachandran S, and Alderson PG.Gum Arabic as a novel edible coating for enhancing shelf-life and improving postharvest quality of tomato (*Solanum lycopersicum* L.) fruit. Postharvest Biol Technol. 2010;58(1):42-47.
[21] Olivas GI, Rodriguez JJ, and Barbosa-Canovas GV. Edible coatings composed of methylcellulose, stearic acid, and additives to preserve the quality of pear wedges. J Food Process Preserv. 2003;27(4):299-320.

[22] Gol NB, Patel PR, Ramana R et al. Improvement of quality and shelf-life of strawberries with edible coatings enriched with chitosan. Postharvest Biol Technol. 2013;85:185-195.
[23] Dávila-AviñaJE, Villa-RodríguezJA, Cruz-Valenzuela Ret al. Effect of edible coatings, storage time, and maturity stage on quality of tomato fruit. American Journal of Agric and Biol Sci. 2011;6(1):162-171.
[24] Anthon GE, LeStrange M, and Barrett DM. Changes in pH, acids, sugars, and other quality parameters during extended vine holding of ripe processing tomatoes. J. Sci. Food Agric. 2011;91(7):1175-1181.
[25] Hernandez M, Rodriguez EM, and Romero CD. Analysis of organic acid content in cultivars of tomato harvested in Tenerife. Eur Food Res Technol. 2007;226(3):423-435.
[26] De Souza ALB, Scalon SPQ, Chitarra MIF et al. Post-harvest application of $CaCl_2$ in strawberry fruits (*Fragariaananassa* dutch cv. Seqnoia): evaluation of fruit quality and post-harvest life. Ciência e Agrotec Lavras. 1999; 23(4):841-848.