

# Does Chitosan Extend the Shelf Life of Fruits?

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## Abstract

The use of hazardous formalin in increasing shelf life of fruits and protecting them from microbial decay by unscrupulous traders is a big health concern for the consumers in Bangladesh. Chitosan is a natural biopolymer produced from the exoskeletons of shrimp and crab, which slows antimicrobial activities and induces immunity of plants against microbial pests. This study aimed to evaluate the efficacy of chitosan on the shelf life extension of some local ripened fruits compared to untreated control. Three doses of chitosan solution viz. 0, 500 and 1000 ppm were sprayed in alternate day on banana (cvs. Shabri and Champa), strawberry, tomato, and oranges. It revealed that chitosan extended shelf life of all fruits by delaying the decay; however, level of protection varied in different kinds of fruits as well as in doses of the chitosan used. Among the tested fruits, decay of tomatoes was most delayed by chitosan. Spraying of both 500 and 1000 ppm of chitosan equally protected 100% decay in tomatoes until 8 days of treatments at room temperature. More than 80% protection of other fruits viz. banana, orange and strawberries by chitosan were recorded at 8, 8 and 4 day after treatment, respectively, which were remarkably higher than the untreated control. Interestingly, 500 ppm of chitosan spray gave better protection than 1000 ppm in all the tested fruits. These results suggest that lower doses of chitosan can be utilized as a natural preservative of fruits alternative to hazardous formalin. A further study with higher number of fruits, and at varying temperature and chitosan doses are needed for recommending it for practical application as a fruit preservative.

## Keywords

Fruit Shelf Life, Alternative to Formalin, Health Hazards, Use of Chitosan, Fruit Preservation

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## 1. Introduction

The detection of formalin in fruits, fishes, and other perishable food items in Bangladesh over the last couple of years poses a serious threat to human health. A 37% solution of gaseous formaldehyde in water is called formalin, which has usually been used to preserve animal tissues, human dead bodies or as a disinfectant. Although coating of fruits by formalin extends shelf life but it is hazardous to human health [1]. Studies in rats and mice using high concentration of formaldehyde over a long period have reported to result in squamous carcinoma of nose [2]. Although taking a good amount of fruits everyday is required for balanced nutrition and sound health, people consumption of fruits has recently been declined significantly due to fear of formalin contamination. Occasionally, the law enforcement agencies discover that a large proportion of fruits available in the market are being contaminated with formalin [3]. Therefore, formalin is now a big threat to human health in this country as increasing number of food items such as fruits, fishes, and vegetables have been found contaminated with this hazardous chemical [4]. No natural, safe, cheap and strong preservative of perishable food items alternative to formalin has so far been discovered in Bangladesh. Therefore, the discovery of a natural and safe preservative for extending shelf life of these perishable fruits and fishes is badly needed. Chitosan has antimicrobial and antifungal activities [5] [6]. It is a linear polysaccharide (a combination of glucose) originating from chitin which comes from the shells of crustaceans including shrimp. Every year Bangladesh exports a lot of shrimp to different countries, but their shells are thrown away as waste. The exoskeleton of this shrimp/prawn can easily be recycled to make chitosan. Recently, the Bangladesh Atomic Energy Commission develops a method of using gamma irradiation to produce low cost chitosan from the shrimp waste, which opens an opportunity for testing this well known natural antimicrobial agent as a safe preservative of fruits [7]. Chitosan is a non-toxic, biodegradable, biofunctional and biocompatible compound. It has no health hazards as it is produced from nature. Chitosan will not create any allergic issues for people who are allergic to prawn as well. Although chitosan has been found as a good agent for reducing the post-harvest loss and extension of shelf life of climacteric fruits in many countries [6], however, scant information is available on the effects of chitosan on shelf life extension of fruits in Bangladesh. The climacteric is a class of fruits that usually undergo dramatic changes during “ripening” and these changes have often been associated with a burst of respiration and ethylene (a natural plant hormone) production [8]. Therefore, the hypothesis of this investigation was that chitosan could enhance shelf life of climacteric fruits as an alternative to hazardous formalin. To test this hypothesis, the objective of this study was to evaluate efficacy of the varying concentrations of chitosan solution on shelf life of orange, banana, strawberry and tomato at room temperature.

## 2. Materials and Methods

### 2.1. Materials and Chemicals Used in the Experiment

Chitosan [2-Amino-2-deoxy-(1→4)-beta-D-glucopyranan] from shrimp shells was purchased from Sigma. Fresh fruits used viz. orange, banana (cvs. Shabri and Champa), strawberry (cv. American Festival), and tomato were collected from the local market of Banani district of Dhaka. Other materials and chemicals used in the investigation were PET bottles (1 L and 500 mL), plastic container (500 ml), distilled water, hydrochloric acid (HCl), sodium hydroxide (NaOH), and pipette tips were available in the laboratory of Department of Biotechnology of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Bangladesh. The glassware and minor equipment used were test tubes, round bottom flasks, pH meter, micro-pipette, spray head and a digital balance.

### 2.2. Preparation of Chitosan Solution

Ten grams of chitosan from shrimp shells (Sigma) was taken in a round bottom flask dissolved in 100 ml of 0.5N hydrochloric acid. The pH of the solution was adjusted to 7.0 by adding 0.5N sodium hydroxide and then diluted with sterilized distilled water (H<sub>2</sub>O) to make the stock solution of 1 L (10,000 ppm). Two working solutions, 500 and 1,000 ppm prepared by appropriate dilution of the stock solution with distilled water. Only distilled water was used as control (0 ppm chitosan).

### 2.3. Application of Chitosan Solution to the Fruits

Four from each kind of fruits (orange, strawberry, banana cv. Sabri, banana cv. Champa, and tomato) washed with tap water. The excess water from the surface of the fruits was absorbed by paper towel tissues before plac-

ing them into a 500 ml plastic container. Three chitosan solutions (0, 500 and 1,000 ppm) were sprayed onto the fruits until wet and then loosely covered the container by a piece of newspaper. Spray application of chitosan on fruits was done in every alternate day and the morphological features of the fruits were observed every day. The observation of fruits decay over time was recorded in a notebook and also photographed every day by a digital camera.

The protection (%) of fruits from decay over time of chitosan treatment was calculated as follows:

Protection (%) from decay = 100 – Decay (%) of fruits under chitosan treatment.

## 2.4. Statistical Analysis

Data obtained were analyzed by using Microsoft Excel software and bar graphs were drawn using the mean values of five replicated experiments.

## 3. Results and Discussion

Chitosan generally delayed the decay of fruits compared to the untreated control. However, the protection of fruits by varying doses of chitosan varied among the tested fruits except tomatoes (**Figure 1**). **Figure 2** shows the time course protection (%) of different fruits by varying doses of chitosan. Interestingly, 500 ppm of chitosan gave better protection (%) in banana (cv. Shabri and Champa), orange and strawberries than 1000 ppm. Doses of chitosan at higher than 500 ppm may affect normal defense mechanism and physiology of the fresh fruits and thus no significant protection was observed by 1000 ppm in current study. Highest percentage of protection by chitosan spray was recorded in tomatoes. The lowest was in strawberries. Irrespective of the doses of chitosan, ripe tomatoes were 100% protected until 8 days of treatment and then gradually decayed. Protection of postharvest fruit decay by chitosan application has been reported [6] [9]-[11]. Among the tested fruits, strawberries decayed at an accelerated rate. However, chitosan at 500 ppm protected about 95% decay until 4 days at room temperature. At the same time, only 80% of fruits remained free from decay in untreated control. Irrespective of the treatments, fruit decay was increased with time; however, rate of decay was significantly reduced by the chitosan application compared to untreated control. Protection of strawberries by 500 ppm at day 6, 8 and 10 were 85, 75 and 40%, respectively which were remarkably superior to all other treatments. Treatment of strawberries with 1000 ppm of chitosan also protected fruit decay but not as effective as 500 ppm. Strawberry protection at day 6, 8 and 10 in 100 ppm treated pots was 80%, 70% and 35%, respectively. In untreated control, decays of strawberries increased faster compared with chitosan treated pots. At day 10, only 90% fruits decayed. Chitosan treatment enhancing strawberry fruit defense responses through phenylalanine lyase enzyme activity [6] [11]. In another study, Zhang and Quantick [12] demonstrated that chitosan coating significantly reduce fruit decay.



**Figure 1.** Chitosan delaying fruit decay over time. From left to right: tomatoes, oranges, bananas and strawberries.

No decay in oranges was observed in any treatment until day 6 (Figure 2). Oranges showed a high level of resistance to natural decay compared to the other fruits. About 90% of fruit decay was prevented by 500 ppm of chitosan at day 8 which was superior to 1000 ppm (85%) and untreated control (80%). Very high decay was observed at day 10 in both 1000 ppm (70%) and untreated control (65%), however, 90% of oranges were protected from decay at that time by the treatment of 500 ppm. Canale Rappussi and co-workers [13] also found that chitosan spray reduces decay of oranges causing black spots on fruits.

Both the cultivars Sabri and Champa of banana displayed a mirror image of each other as their rate of protection was constant until day 6 at 1000 ppm (90%), 500 ppm (100%) and untreated control (90%) (Figure 2). In day 8, both cultivars of bananas protected from decay at the same rate, with 1000 ppm (90%), 500 (95%) and untreated control (85%). Differences in protection were only noticeable in day 10, when the Sabri bananas decayed quickly in untreated control (45%), 500 ppm (60%) and 1000 ppm (55%) of chitosan. Champa bananas were protected by chitosan from decay slightly at a slower rate, with untreated control (50%), 500 ppm (70%) and 1000 ppm (70%). Chitosan with gum arabic enhance the shelf life of banana has been reported [14] [15] through reducing the respiration by 32% [10] [16] [17]. Baez-Sanudo and co-workers [10] reported that chitosan coating did not affect the sensory quality of banana.

Chitosan spray was found best in protecting tomatoes compared with other fruits tested. Irrespective of the doses of chitosan spray, 100% protection of decay was observed until 8 days after the treatment. However, slight decay of untreated control (10%) occurred at day 4, which persisted until day 8. The untreated control tomatoes decayed to 30% at day 10, displaying the slowest rate of decay among all the other fruits at this day. In day 10, 500 ppm and 1000 ppm tomatoes succumbed to decay slightly (5%) (Figure 2). Romanazzi and his co-workers [6] reviewed the protection of tomatoes and other fruits by the application of chitosan.

This study demonstrated that chitosan protected fruits from decay at room temperature. Bangladesh is rich in production of shrimp in the Southern region. Exoskeleton of the exported shrimp is a waste. It can be utilized to produce chitosan and utilize this waste into a safe fruit preservative. As chitosan is an antimicrobial agent

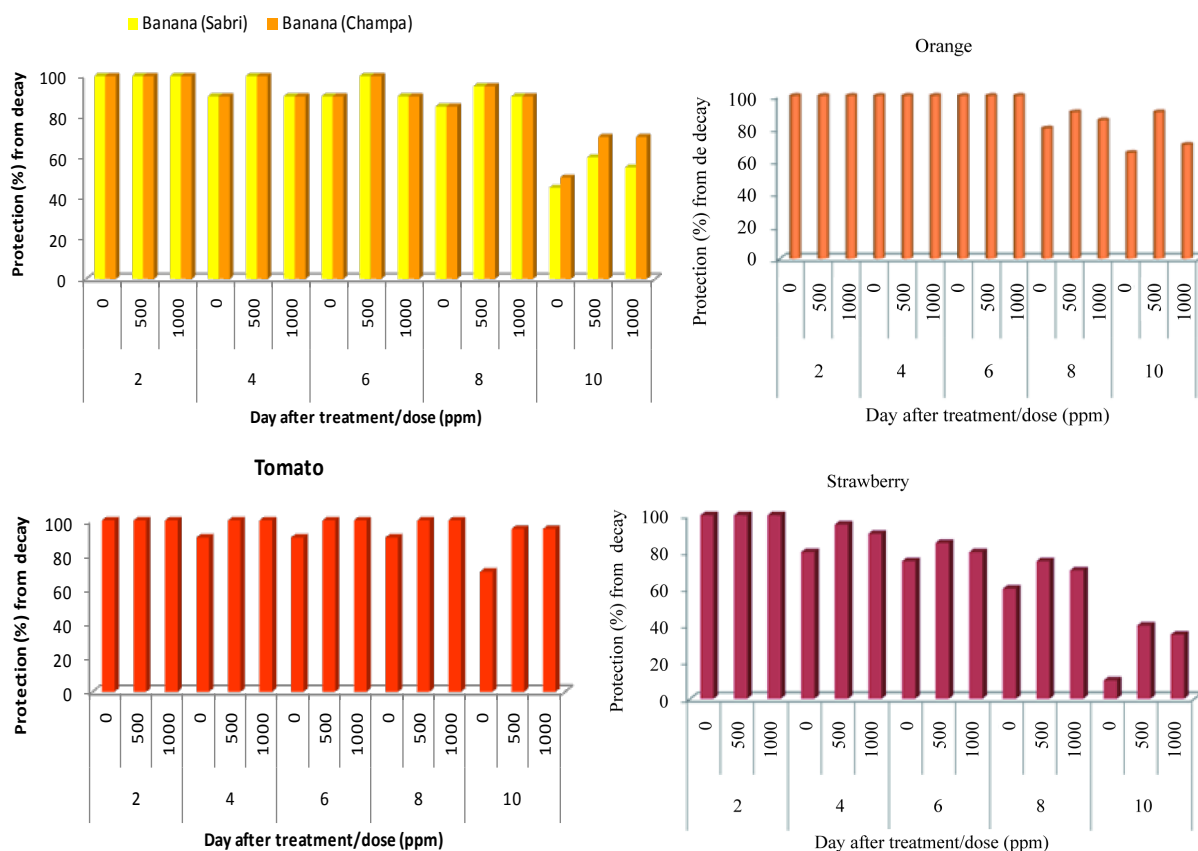


Figure 2. Time-course protection (%) of strawberry, orange, banana and tomato by varying doses (ppm) of chitosan sprayed.

against many plant pathogenic fungi and bacteria, protection of fruit decay observed in this study is likely to be linked with its antimicrobial activity [7]. Moreover, chitosan induces systemic resistance in plants [18]. Formalin is a health hazardous chemical [1], which has been suspected to use in fruit preservation in Bangladesh. The preliminary findings of delay in fruit decay by chitosan demonstrated in this study suggest that the natural chitosan could be used as a safe alternative to formalin. Chitosan has also previously been successfully used in enhancing shelf life of several postharvest fruits and vegetables, such as jujube and strawberry [6] [19] [20]. Bios-timulant activity and disease resistance in horticultural crops by chitosan and their putative mode of action have recently been reviewed [21]. In a recent study, Zhang *et al.* [22] demonstrated that controls of postharvest decay on cherry tomato fruit by chitosan is linked with the mitogen-activated protein kinase signaling pathway. However, a further investigation is needed with varying doses of chitosan on higher amount of varying fruits under different storage conditions for precise recommendation of its use in fruit preservative.

#### 4. Conclusion

Chitosan spray remarkably enhanced shelf life of strawberry, tomato, orange and bananas under room temperature. However, the type of fruit seemed to be an important factor, as strawberries showed more signs of decay than bananas. Interestingly, the fruits infused with 1000 ppm chitosan possibly had some side effects as some rotted even faster. The fruits which were soaked with 500 ppm produced the best results, as they still looked fresh with no signs of rotting. The fruits treated with only water decayed faster and normally. Too much of chitosan may actually be very bad for some fruits such as strawberries or tomatoes. The findings of the current study might be useful for replacing the use of health hazardous formalin by natural alternative and eco-friendly chitosan.

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