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Stability Enhancement of Fruits and Vegetables using Chitosan Coatings.

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ABSTRACT

Post harvest spoilage of fruits and vegetables is a common major problem and ways to reduce this spoilage are constantly explored. Chitosan is a natural polymer which obtained from deacetylation of chitin. It is a versatile polymer and its coating has proved to increase the shelf life of the fruits and vegetables. Present review summarizes different fruits and vegetables whose shelf-life has been increased using chitosan coatings. The coating being biodegradable and non-toxic for consumption has wide applications in the near future.

Keywords: Chitosan, coating, mangoes, raspberries, tomatoes.

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INTRODUCTION

Introduction to stability of vegetables and fruits:

Post harvest spoilage of fruits and vegetables is a major problem in most of the developing countries which eventually leads to economic losses also. Fruits and vegetables are highly perishable products which should be handled with great care to minimize losses. Wastage of agricultural products due to improper handling, packaging and storage leads to almost 20-25% of economical loss in developing countries. Horticulture products are biologically active and carry out respiration, transpiration and other such biochemical processes which cause quick deterioration of these products. Respiration is an important biochemical activity in a harvested fruit and should be controlled to increase shelf life of the harvested product. Proper packaging and storage are important post harvesting activities as they can reduce losses if carried out with due precaution [1,2].

Introduction to chitosan:

Chitosan is a versatile natural polymer. It has gained popularity in various fields because of its easy availability, lesser costs and adaptability. Chitosan is a polysaccharide derived by alkaline deacetylation of chitin. Chitosan is generally regarded as a biodegradable, biocompatible and non-toxic biomaterial. Chitosan a linear polymer consists of (1,4)-linked 2-amino-deoxy-β-D-glucan. Chitosan has antibacterial, antifungal properties and hence is an ideal film forming agent. The deacetylation of chitin is usually not complete, so chitosan is generally a copolymer that comprises of D-glucosamine N-acetyl-D-glucosamine. Chitin is a hard, white, inelastic, nitrogenous polysaccharide found in exoskeleton of some invertebrates [eg: - fishes, crabs, shrimps, lobster]. Chitosan's charge density generally depends upon degree of deacetylation and pH. It is soluble in dilute aqueous acidic solutions like that of acetic acid. Chitosan is commercially obtained from different suppliers in varying degree of purity, molecular weight and degree of decetylation[3].

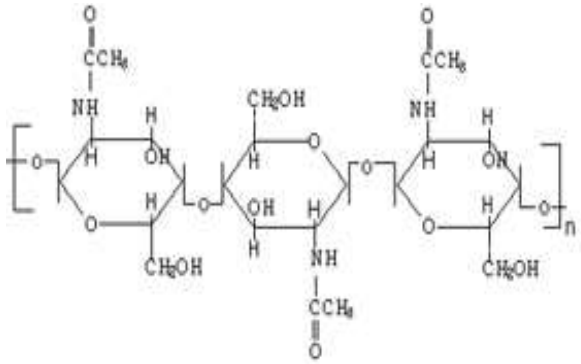

Figure 1: Structure of chitosan.

Advantages of chitosan:

Chitosan has various advantages over other synthetic biopolymers. They are mentioned below:

1. Chitosan is a bio-degradable natural polymer with good film forming properties.
2. It is more cost effective as compared to present day synthetic polymers.
3. Chitosan has anti-bacterial and anti-fungal properties which are essential in packaging of fruits and vegetables after harvesting.
4. Chitosan is non-toxic in nature and hence is edible.
5. Chitosan films provide good barrier properties against lipids and gases.

Disadvantages of chitosan:

Chitosan has minimal disadvantages that can be overcomed by addition of different substances. Limitations of chitosan and methods to overcome them are given below:

1. Chitosan films are brittle in nature. This limitation can be overcome by addition of glycerine or other such plasticizers.
2. Chitosan films provide poor barrier against permeability of water vapour. Incorporation of lipid compounds and waxes can help overcome this limitation.

Applications of chitosan:

Applications of chitosan have been reported since decades in various fields. The following are applications of chitosan:

1. Chitosan may help in inhibiting fibroplasias in wound healing and can promote tissue growth and differentiation in tissue culture.
2. Chitosan is a natural substance that can be classified as hydrocolloids and used in stability enhancement.
3. Chitosan is used to enhance stability of different drugs and is used as a penetration enhancer.
4. Chitosan nanoparticles, microspheres and encapsulation of drugs in chitosan increases stability and bioavailability of drugs like insulin, metformin etc.
5. Chitosan has good film forming properties and it is used in packaging industries to increase shelf life of perishable agricultural products [4].

Role of chitosan in increasing stability of vegetables and fruits:

Chitosan coatings are being considered as the future packaging techniques to increase shelf life of perishable products post harvesting. Chitosan films inhibit biochemical activities of live cells of fruits and vegetables which are mainly responsible for quick deterioration and senescence of agricultural products. Chitosan being economical and non toxic is a good edible film forming

agent. Chitosan coatings have been checked for increasing of stability of various fruit products like mangoes, strawberries, raspberries, tomatoes, apples and other fruits and vegetables. Coating methods, disadvantages, advantages of chitosan coatings for different food products are given below [5].

Stability enhancement of mangoes using chitosan coatings:

Mango is a seasonal, highly perishable product which should be stored and packed properly to increase its shelf life and retain its palatability for longer period. Nadeem Akhtar Abbasi et al worked on enhancing stability of mango in the following way: [6]

Methods and materials used in coatings:

Fruits carefully selected after harvesting were washed with distilled water, air dried and packed into corrugated boxes. Fruits were coated with different types and concentrations of chitosan. Uncoated fruits, fruits coated with 1.5% irradiated chitosan [100 kyG], fruits coated with 1.5% irradiated chitosan [200 kyG] both obtained from crab skeleton, fruits coated with 1.5% non-irradiated chitosan and fruits coated with shrimp chitosan were all stored at 15ºC ± 1ºC at 85% RH for six weeks. Fruits were evaluated at regular intervals of 6-7 days. Dipping method was used in coating mango fruits [7].

Evaluation methods and results:

Various different evaluation tests like physical tests, chemical tests and qualitative analysis were performed on mango fruits as stated below:

1] % Weight loss:

Fruits were weighed before and after application of coating and stored for 6 weeks and weighed at after intervals of 6-7 days. It was found that uncoated fruits had maximum weight losses. Fruits coated with 1.5% irradiated chitosan [100kyG] showed lesser weight loss when compared with uncoated mangos. 1.5% irradiated chitosan [200kyG] had minimum weight losses. Hence it can be concluded that films containing higher concentrations of chitosan were found effective in reducing weight losses.

2] Firmness of fruit:

As mango approaches senescence it tends to lose its firmness. This property of the fruit was evaluated after specific periods. It was found that fruits coated with chitosan [200 kyG] were firmest among all other fruits. Firmness of the coated fruit was mainly because inhibited transpiration and respiration of the fruit skin due the impermeability of chitosan film [8].

3] Moisture content and effect on browning:

It was found that chitosan coatings on cut surface helped in retaining moisture and delayed browning of the fruit.

4] Total soluble solid content and respiration rate tests:

It was found that fruits coated with higher concentrations of chitosan had higher amounts of total soluble solids. Respiration rate was found decrease considerably as compared to other uncoated fruits.

5] Qualitative analysis:

Aroma of coated mangoes was found to be better than their uncoated counterparts by analysts. Taste of coated and uncoated mangoes was compared by the analysts and it was found that taste of former was better than later [9].

Stability enhancement of strawberries and raspberries using chitosan coatings:

Strawberries and raspberries are highly nutritious fruits but with a very short shelf life due their high physiological activities even after harvesting. To add to their short ripening and senescence period, strawberries and raspberries are highly susceptible to fungal attacks. Thus packaging and storage should be given importance in post harvesting activities of these fruits to increase their shelf life. Chitosan coatings were tried as an effective packaging technique which helped in increasing the shelf life and palatability of these fruits as stated below [10].

Methods and materials used in coating:

Three varieties of strawberries and one variety of raspberries were taken for experiment of stability testing. The fruits were coated with three different types of chitosan coatings viz. chitosan, chitosan containing 1.5% calcium gluconate and chitosan containing 0.2% vitamin E. The fruits were coated by dipping them twice in the respective solutions for 10 seconds. The fruits were dried for 30 mins after first dipping and then for 60 mins after second dipping under fan to ensure complete drying. The fruits were packed in clam shell plastic containers and stored at 2ºC with 88% RH for 6 weeks. They were tested after specific intervals and results were obtained as given below: [11]

Evaluation methods and results:

1] % weight loss:

% weight loss was considered as an important parameter to evaluate efficiency of chitosan coatings. Fruits were weighed before and after coating and later the weight was checked after

regular intervals with help of electronic balance. It was found that weight loss amongst coated fruits was less as compared to uncoated fruits.

2] % drip loss:

% drip loss was measured using electronic balance by weighing the fruits prior storage and then after regular intervals. Drip loss was successfully reduced by 24% amongst coated fruits.

3] Water vapor permeability measurement:

Permeability of water vapor was studied using techniques mentioned in Mei and Zhao (2003). It was found that water vapor loss was minimum in fruits coated with chitosan as compared to uncoated fruits.

4] Chemical constituents:

Chemical constituents like concentrations of calcium and alpha-tocopheryl in the fruits was studied. It was found by using different analytical methods that fruits coated with chitosan had higher contents of calcium and alpha-tocopheryl as compared with uncoated fruits.

5] Firmness of fruit:

Firmness of both coated and uncoated fruits were analyzed but specific results regarding effect of chitosan coating on this parameter were not obtained.

6] Color of the fruits:

Color of the fruits was studied using Hunter Labscan colorimeter and the results obtained showed that fruits coated with chitosan had better color as compared to uncoated strawberries and raspberries [12, 13].

Enhancement of stability of tomatoes using chitosan coatings:

Tomato is a fruit obtained all around the year but peak season of production of tomato is from September to November. It is quickly perishable commodity hence should be properly packed and stored to decrease losses incurred due to deterioration of tomato. Lycopene is an active constituent found in tomato which of medicinal importance also. Chitosan combined with other chemicals was used in coating of tomatoes and their stability was evaluated as follows [14]:

Method of coating and material used:

Solutions of 1% or 2% chitosan were prepared with 0.6% of acetic acid 25% of glycerol as plasticizer and varying amounts of lysosyme. The fruits were dipped in different solutions for 10 seconds and then air dried. Later tomatoes both coated and uncoated were stored properly at around 22ºC. The fruits were then subjected to evaluation tests after specific intervals as follows: [15]

Evaluation tests and results:

1] % weight loss:

% weight loss was evaluated using electronic weight balance. Weights of fruits prior to storage and weights recorded during storage after specific interval were compared. It was noted that % weight loss amongst uncoated fruits was more as compared to coated fruits which showed minimal weight loss.

2] Firmness of the fruits:

Firmness of the fruits was checked using penetrometer. It was found that coated tomatoes had firmer films as compared to uncoated tomatoes.

3] Respiration rate:

Respiration rate of tomatoes was studied by sealing them in 1 liter suitable medium and then checking the concentration of CO_2 using chromatography technique. It was found that concentration of carbon-dioxide in containers with coated tomatoes was less than containers sealing uncoated tomatoes. Thus we can conclude that chitosan coated tomatoes showed lower rates of respiration.

4] Color and appearance:

Color and appearance of coated tomatoes was checked using Minolta chromatometer and results obtained showed that tomatoes coated with chitosan films had better color and appearance as compared to uncoated tomatoes.

5] Shrinkage:

Shrinkage of tomato skin was studied with suitable analytical method and it was found that tomatoes coated with higher concentration of chitosan films had minimal shrinkage as compared to others [16].

Future trends:

Chitosan a biopolymer which is versatile in nature and has different properties is being evaluated for future packaging techniques. Due to its efficient film forming properties, anti-microbial nature, non-toxicity it can prove to be an excellent packaging material. Because chitosan is economical small scale farmers will also benefit with this newer technique. Currently though not used commercially chitosan coatings are being evaluated by coating different agricultural products. Also different combinations are being worked out to increase the efficiency of chitosan films and making them more feasible.

CONCLUSION

Use of edible films on food products continues to expand because of potential benefits like antimicrobial properties, flavors and antioxidants. Natural coating materials like chitosan can compete both in price and in performance with synthetic coating materials. Various experiments and researches prove that chitosan film coatings are capable of increasing the shelf-life and palatability of certain fruits. Chitosan coatings have proved capable in reducing biochemical activities like respiration and transpiration of the harvested fruits which are major cause of fruit deterioration. Chitosan coatings also improve the outer appearance of fruits i.e properties like their color, firmness etc which in turn has increased consumer acceptability.

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