ejpmr, 2016,3(9), 558-570

SJIF Impact Factor 3.628

EUROPEAN JOURNAL OF PHARMACEUTICAL AND MEDICAL RESEARCH

www.ejpmr.com

Research Article

ISSN 3294-3211

EJPMR

GUAR GUM BASED EDIBLE COATING ON CUCUMBER (*CUCUMIS SATIVUS* L.)

Anuradha Saha[1], Shvetambri Tyagi[2], Rajinder K. Gupta[3] and Yogesh K. Tyagi[1*]

University School of Basic and Applied Sciences[1],
University School of Biotechnology[3],
Guru Gobind Singh Indraprastha University, Sector 16C, Dwarka, Delhi-110078, India
[2]Bhaskarcharya College of Applied Sciences, University of Delhi, Sector 2, Phase 1, Delhi-110075, India.

***Correspondence for Author: Dr. Yogesh K. Tyagi**

University School of Basic & Applied Sciences, Guru Gobind Singh Indraprastha University, Sector 16C, Dwarka, Delhi-110078, India.

Article Received on 19/07/2016 **Article Revised on 08/08/2016** **Article Accepted on 29/08/2016**

ABSTRACT

In this study, the application of guar gum based edible coating on quality and shelf life of cucumber (*Cucumis sativus* L.) vegetables during storage at ambient conditions (25±2˚C and 70±5%) was investigated. The formulations consist of guar gum, carboxymethyl guar gum, potassium sorbate, cinnamon oil, glycerol, water and an emulsifying agent. Different quality parameters were monitored to evaluate the coating effects. The parameters included weight loss, decay loss, soluble solids, ascorbic acid content, pH, titratable acidity, juicability, total phenolics, antioxidant activity and microbial activity evaluation. The coating reduced the weight loss, decay loss, acidity, total phenolics, relatively maintained the antioxidant activity, decreases the microbial infection and thereby increased the post harvest storage life of cucumbers at ambient conditions (25±2˚C and 70±5%).

KEYWORDS: Edible coating, Shelf life, Quality, Cucumber, Guar gum.

INTRODUCTION

The cucumber (*Cucumis sativus* L.) is commonly cultivated plant belongs to the *Cucurbitaceae* family. It is one of the most popular crops all over the world, mainly cultivated during the summer season. Cucumber's production in the world is over 40,000 tonnes, where China is the lead producer, followed by Turkey, Iran, Russia and Ukraine (FAO, 2005). In India, it is mainly grown in Karnataka, Andhra Pradesh, Assam, Bihar, Jammu and Kashmir, Punjab, Odisha, Madhya Pradesh, Kerala and Rajasthan in summer seasons with relatively good production rate and is one of the most important market vegetable (FAO, 2005; Horticulture statistics Division, DAC&FW). However, this crop can also be grown throughout the year in the wet zone. It is mainly consumed as raw vegetable as a salad. The price of cucumbers was high during low production period and during the peak production period. These price fluctuations can be overcome and export of cucumber can be increased by adopting various storage techniques. However, cucumber is a perishable vegetable as visual and sensory quality deteriorates rapidly. Moreover, cucumber production is also affected by the attack of certain parasites called downy mildew and fungal diseases called powdery mildew (Anand et al. 2008). This particular infection has been seen in plants belongs to *cruciferae* family, grapes and vegetables that grow on vines. Shrivelling, yellowing and decay are likely to increase after storage of more than a week. It has also been seen that cucumbers are very sensitive to chilling injury when stored at temperature lower than 10ºC (Kasim and Kasim, 2011). To extend their shelf life and maintain their quality during storage, several treatments are already being used for enhancing the post-harvest life of these vegetables such as chemical preservatives, fungicides, modified atmosphere packaging and controlled atmosphere packaging, however, these methods of preservation has some drawbacks. Firstly, they are less economical, secondly, they are non-biodegradable, thirdly modified atmosphere packaging in cucumber, sometimes alleviates chilling injury (Wang and Qi, 1997) and lastly, these synthetic fungicides and pesticides are harmful for human consumption and in the course of time, these fungicides develops tolerance to diseases.

Edible films and coatings are an environmental friendly natural method to increase the postharvest storage life of fresh fruits and vegetables (Vargas et al. 2008; Bourtroom, 2008). Edible coating has many advantages over other methods of preservation. It is environmentally friendly, more economical, found naturally abundant in environment. Edible coating form a semi-permeable barrier to gases and water vapour on the food surface, thereby reducing weight loss and preserve inner quality of food during storage. In addition, it provides gloss to the coated vegetables (Hagenmaier and Shaw, 1992). Mainly, carbohydrate based polysaccharides, proteins and lipid such as sucrose esters, fatty acids are used as edible coating material (Bourtroom, 2008).

Mehyar et al. (2011) and Mehyar et al. (2014) suggested that natural polysaccharides like guar gum as edible coatings are suitable substance to carry food preservatives like potassium sorbate (GRAS salt) and essential oil, thereby improving the antifungal activity of edible coatings and potassium sorbate as a preservative agent. They further reported that guar gum edible coatings when combined with potassium sorbate retained potassium sorbate concentration on the surface of produce, which proves effective against moulds isolated from selected vegetables and protect potassium sorbate from disappearance during storage. The high viscosity of guar gum solutions (concentration of 1.0% (w/v)) may be responsible for producing a film on the surface of food commodity (Srichamroen, 2007) which helps in extending the shelf life of the produce. Guar gum coatings indicate the largest concentration of potassium sorbate on surface of apples and tomato compared to other polysaccharides such as starch (Mehyar et al. 2011, Mehyar et al. 2014). Recent studies have shown that guar gum edible coatings improved the quality and shelf life of persimmon and tomato vegetables during storage (Saha et al. 2015, Ghosh et al. 2014).

Pectin based edible coating containing essential oil reduced the decay of coated vegetable stored at ambient conditions and extended its shelf life (Velasquez et al. 2014). Essential oils are natural hydrophobic liquid or plant extract with a characteristic aroma that possess antifungal activity and have been used widely in edible coatings to improve coating's antifungal activity (Burt, 2004). Pectin based edible coating containing essential oil reduced the decay of coated vegetable stored at ambient conditions and extended its shelf life (Velasquez et al. 2014). Edible coating enriched with essential oil as well as conventional Fungicide works well in reducing vegetable vegetable postharvest decay such as lemon and its total micro-flora content present on the food surface (Castillo et al. 2014; Palou et al. 2015). We have used cinnamon oil as an antifungal ingredient in edible coatings. Cinnamon oil is derived from *the Cinnamomum zeylandicum* plant which contains trans-cinnamaldehyde and cinnamic acid as an active ingredient (Lens-Lisbonne et al. 1987). Burt (2004) reported the decreasing order of antifungal potency of essential oil incorporated in food system which was in the order: oregano/clove/coriander/cinnamon>thyme>mint>rosemary>mustard>sage. In view of the above, cinnamon oil is one of the most potent antifungal essential oil. Hence, we have used cinnamon oil as an antimicrobial agent in our guar gum based edible coatings.

Commercial wax coating though improves appearance and reduces weight loss, it also results in the development of off-flavors, which are the result of inhibition of oxygen and carbon dioxide exchange, thereby resulting in anaerobic respiration (Hagenmaier and Shaw, 1992; Chen and Nussinovitch, 2001). Hence, edible coatings based on guar gum and carboxy-methyl guar gum has been developed using antifungal essential oil like cinnamon and GRAS preservative such as potassium sorbate.

Guar gum is chemically modified into carboxymethyl guar gum, an anionic derivative of guar. The presence of hydroxyl group in the structure of guar gum provides a suitable substrate for carboxy-methylation reaction (Pal, 2009). Among many guar gum derivatives, carboxy-methyl guar gum covers a wide range of industrial application (Gong et al. 2012). Hence, we have attempted to use carboxy-methyl guar gum as an edible coating together with guar gum to study the shelf life of cucumbers cv malini. Malini varieties of cucumber are produced in significantly higher numbers and with higher yield.

MATERIALS AND METHODS

The guar gum was obtained as a gift sample from Hindustan Gum & Chemicals Ltd., Bhiwani, India. The fresh cucumbers (cv. Malini) were selected on the basis of uniform sizes, appearance, colour, same degree of ripeness, free from rots and defects brought into the laboratory as soon as it was harvested. They were washed with 0.1% sodium hypochlorite, cleaned and kept in air drying before coating applications. Tween-80 and glycerol was obtained from High Media (Mumbai, India) and used as plasticizer.

Preparation, composition and application of edible coatings

To prepare edible coating solutions, 1 g guar gum was mixed with 100 ml of distilled water. 1g carboxy-methyl guar gum was also mixed with 100ml distilled water and both were stirred continuously and uniformly on a magnetic stirrer. Glycerol as plasticizer (35% w/w) and tween-80 (0.1% w/w) as surfactant was added into the solution. The other variation of guar-gum coating solution (guar-gum+cinnamon oil and carboxy-methyl guar gum+cinnamon oil/potassium sorbate) was prepared similarly with incorporation of 0.1% w/v cinnamon oil and potassium sorbate (compositions given below). The cucumbers were coated by brushing method, and then the residual solution was allowed to drip off for a minute. When the cucumbers get completely dried after coating, they were kept at 25±2˚C and 70±5% for periodical analysis. The cucumbers were divided into seven sets of different coating combinations, while the eighth group was control (uncoated) cucumbers. The compositions were described as follows:

Coating A: Carboxymethyl guar gum (1%) + potassium sorbate (0.4%) + glycerol (35%w/w) + tween 80 (0.1%)
Coating B: Carboxymethyl guar gum (1%) + cinnamon oil (0.1%) + glycerol + tween 80 (0.1%)
Coating C: Carboxymethyl guar gum (1%) + potassium sorbate (0.4%) + cinnamon oil (0.1%) + glycerol (35% w/w) + tween 80 (0.1%)
Coating D: Guar gum (1%) + potassium sorbate (0.4%) + glycerol (35% w/w) + tween 80 (0.1%)
Coating E: Guar gum (1%) + cinnamon oil (0.1%) + glycerol (35%) + tween 80 (0.1%)

Coating F: Guar gum (1%) + potassium sorbate (0.4%) + cinnamon oil (0.1%) + glycerol (35%) + tween 80 (0.1%)
Coating G: Commercial coating
Control: Uncoated

Physicochemical analysis
Physiological weight loss: Weight loss (%) was expressed as the percentage loss of initial weight (Hasan et al. 2013). Weight loss was measured from the initial weight calculated using the formula:
Weight loss (%) = [(Wi-Ws)/Wi] × 100,
Where, Wi = initial weight
Ws = weight at sampling period

Decay percentage (%)
The number of decayed vegetables in both coated and uncoated cucumber vegetables were observed and visually inspected throughout the storage period. The decay percentage (percentage of vegetables infected/decayed) was determined as the number of vegetables damaged, divided by the total number of vegetables initially multiplied by 100 (El-Anany et al. 2009). Cucumber vegetables that showed fungal development were considered decayed.

pH
The pH was determined by the method described by (AOAC, 2000) using a digital pH meter (Thermo-Fisher). Cucumber juice was extracted using juice extractor and muslin cloth. The juice of both coated and uncoated cucumbers were separated for measuring the pH.

Total soluble solids (TSS)
A total soluble solid refers to amount of sugars and acids together with small amounts of vitamins, minerals and amino acids present in vegetables. The total soluble solids of both coated and uncoated cucumbers were determined by digital refractometer (Atago, Japan) and expressed as ˚Brix (AOAC, 2000). Individual cucumber vegetable from each of the treatment was grounded in a juice extractor for extracting freshly prepared juice for analysis.

Titratable acidity analysis
The titratable acidity was calculated as the volume (ml) of sodium hydroxide (0.1 mol/L) required for titrating 10 mL of the diluted juice sample which was homogenized to 100 mL of water for titration. The results were expressed as percentage of citric acid (AOAC, 2000). Since citric acid was found to be the predominant organic acid in cucumber, the milli-equivalent factor used here was that of citric acid that is 0.064.

Ascorbic acid content
Ascorbic acid content was determined using 2, 6-dichlorophenol indo-phenol dye methods described by (AOAC, 2000).

Total Phenol content estimation
Total phenolic content of both coated and uncoated (control) cucumber samples were obtained by Folin-Ciocalteu method (Cliffe et al. 1994). 0.1 ml of extract was diluted with 1.150 mL of distilled water and 0.25ml of Folin-Ciocalteu reagent was added and mixed uniformly followed by the addition of 1.5 mL of 20% sodium carbonate and the mixture was incubated in dark at room temperature for 2 h. The mixture was then diluted by 2 mL of distilled water and the absorbance of standard (gallic acid: 10-50 µg/mL), extracts of cucumber (conc. 30 mg/mL) was determined by spectrophotometer at 765 nm against DMSO blank. The mean of the three readings was calculated and the total phenolic content was expressed in µg of GAE (gallic acid equivalent) per mg of weight of extracts.

Antioxidant activity evaluation
A modified method of DPPH **(**1,1-diphenyl-2-picryl hydrazyl) radical scavenging activity was used to evaluate the free radical scavenging activity of extracts in solution as used by (Shen et al. 2010) to evaluate its antioxidant activity. 100 µL of the cucumber sample was mixed with 1ml of 0.1 mL DPPH (prepared in methanol). The reaction mixture was incubated under dark conditions for a period of 45 min at 37˚C. The change in colour intensity of reaction mixture was measured spectrophotometrically by recording the absorbance of the standard (gallic acid), extracts of cucumber (conc. 10-30 mg/ml) at 517 nm against methanol as blank.
% radical scavenging activity = [{Control (O.D.) – Sample (O.D)}/Control (O.D.)] ×100
Where, Control (O.D) = absorbance of control
Sample (O.D) = absorbance of coated and uncoated cucumber sample.

Evaluation of Juicability
The sample was first weighed on a digital weighing balance and chopped into small pieces. The sample is then grinded in a mixer-grinder followed by filtration of juice from the grinded sample using muslin cloth. The amount of juice extracted was measured at each storage interval to report the juicability of control (uncoated) and coated samples as ml/100g of the vegetable.

Anti-bacterial activity evaluation
The prepared nutrient agar (NA) plates were incubated at 37˚C for 24 h. Different food-borne bacteria (*E. coli*, *P. mirabilis*, *S. flexeneri*, *S. aureus*, *B. subtilis*, *S. enterica*, and *S. epidermis*) were inoculated in nutrient broth which was kept at incubator shaker at 37˚C for 24h. 100 µl of the respective culture was spread over the NA plates. The antibacterial activity of the different coating solutions were evaluated by agar well-diffusion method. The antibacterial activity of the coating solution was

obtained by measuring the diameter of the zone of inhibition caused by the respective coating solution and the mean values were calculated.

Statistical analysis

The data obtained were subjected to variance analysis (ANOVA) and mean comparison of the results were done by Tukey's test with 5% level of significance.

RESULTS AND DISCUSSION

Physiological weight loss

Weight loss in fresh produce is mainly because of the loss of water caused by transpiration and respiration (Zhu et al. 2008). This leads to shrivelling and wilting of vegetables which reduces the commodity's marketability, hence act as a limiting factor for marketability. Edible coating reduces transpiration and respiration by forming a semi-permeable layer (Dong et al. 2004) and can be used as a protective barrier. Vegetables coated with guar gum, cinnamon oil and potassium sorbate presented better results for weight loss when compared to other coating treatments. Temperature and relative humidity play a crucial role in providing the driving force for loss of moisture in terms of water vapour pressure difference between vegetable and its surrounding atmosphere. In the present study, the percentage weight loss was found to significantly (p<0.05) increase with storage time for control as well as coated cucumber. However, edible coating when applied delays the weight loss of cucumber vegetable during storage compared with control cucumbers (Figure 1). The weight loss was found to be highest for control (uncoated cucumbers) showing maximum weight loss of 11% at the end of storage period. Combination of guar gum with potassium sorbate and cinnamon oil most efficiently reduced moisture loss from vegetable throughout storage with only 7.12 % weight loss followed by anionic guar gum (AGG) (Fig.1). Oluwaseun et al. (2013) reported similar results in corn starch and carboxy-methyl cellulose coatings in cucumber which was kept at ambient conditions and also by (Adetunji et al. 2014) who found that chitosan in combination with aloe-vera coated cucumbers also delayed the weight loss in cucumbers as compared to control (uncoated) cucumbers.

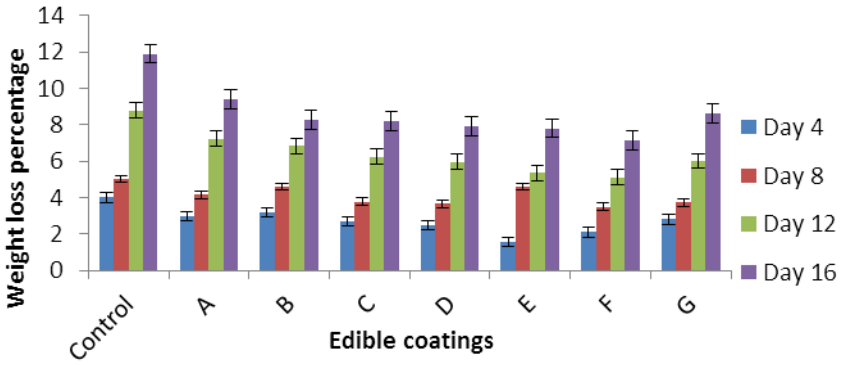

Figure 1: Weight loss percentage of coated and uncoated cucumber stored at ambient conditions (25±2˚C, 70±5% R.H.) (where, Coating A: Carboxymethyl guar gum (1%)+potassium sorbate (0.4%)+glycerol (35%w/w)+tween-80(0.1%), Coating B: Carboxymethyl guar gum(1%)+ cinnamon oil(0.1%)+glycerol+tween-80 (0.1%), Coating C: Carboxymethyl guar gum(1%)+ potassium sorbate (0.4%)+cinnamon oil (0.1%)+glycerol (35% w/w)+tween-80 (0.1%), Coating D: Guar gum(1%)+potassium sorbate (0.4%)+glycerol (35% w/w)+tween-80 (0.1%), Coating E: Guar gum (1%)+cinnamon oil (0.1%)+glycerol (35%)+tween-80 (0.1%), Coating F: Guar gum (1%)+ potassium sorbate (0.4%)+cinnamon oil (0.1%)+glycerol (35%)+tween-80 (0.1%), Coating G: Commercial coating, Control: Uncoated) [The vertical bar represents standard error of the means].

Decay percentage

Figure 2 shows the decay percentage of uncoated and coated cucumber vegetables at ambient conditions during the storage period. The results indicate that edible coatings from guar gum and modified guar gum with cinnamon oil effectively controls the decay percentage by controlling the growth of fungal infection during the storage period as cinnamon oil is an essential oil which act as an antifungal agent. No sign of decay was found at the beginning of the storage period. However, it was found during observation that the control cucumber deteriorated faster than coated cucumber due to protective effects of edible coatings that is percentage of fungal infection was less in coated vegetables. Decay percentage of control vegetables were 80% at the end of storage period. Guar gum coating in combination with potassium sorbate and cinnamon oil (coating F) and commercial coating found to be most effective and coating A proved less effective in reducing the decay percentage of cucumbers. Marpudi et al. (2011) also found that aloe-vera gel based antimicrobial coatings reduces the decay percentage of papaya and extend the shelf life than uncoated papaya. (Oriani et al. 2014) reported that the addition of cinnamon oil to the cassava starch coating inhibited the growth of microorganisms like *Staphylococcus aureus* and *Salmonella choleraesuis.* The decrease who studied in the percentage decay of coated vegetables was may be due to the effects of these

coatings on delaying senescence (Patrícia et al. 2005). Patrícia et al. (2005) also reported the same on strawberry.

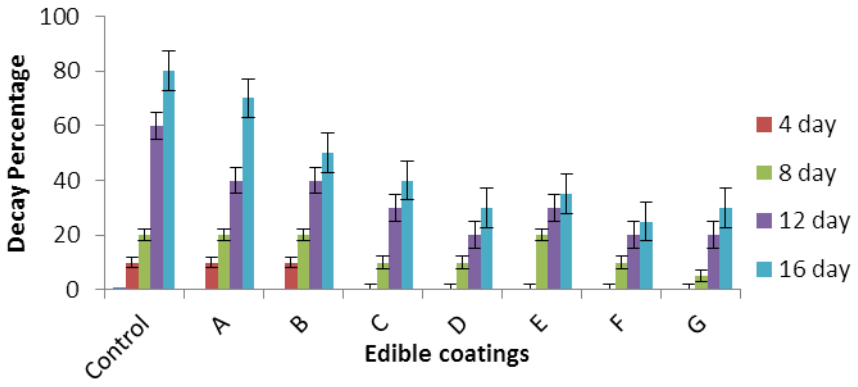

Figure 2: Decay percentage of coated and uncoated cucumbers stored at (25±2˚C, 70±5% R.H.) (where, Coating A: Carboxymethyl guar gum (1%)+potassium sorbate (0.4%)+glycerol (35%w/w)+tween-80(0.1%), Coating B: Carboxymethyl guar gum(1%)+ cinnamon oil(0.1%)+glycerol+tween-80 (0.1%), Coating C: Carboxymethyl guar gum(1%)+ potassium sorbate (0.4%)+cinnamon oil (0.1%)+glycerol (35% w/w)+tween-80 (0.1%), Coating D: Guar gum(1%)+potassium sorbate (0.4%)+glycerol (35% w/w)+tween-80 (0.1%), Coating E: Guar gum (1%)+cinnamon oil (0.1%)+glycerol (35%)+tween-80 (0.1%), Coating F: Guar gum (1%)+ potassium sorbate (0.4%)+cinnamon oil (0.1%)+glycerol (35%)+tween-80 (0.1%), Coating G: Commercial coating, Control: Uncoated) [The vertical bar represents standard error of the means].

pH and Titratable acidity

The coated and control cucumber juice was determined for their titratable acidity and pH value at the end of each storage period. The results (Figure 3a) showed that cucumber stored at ambient condition exhibit a gradual decrease (non-significantly) in pH with the increase in storage period for control and coated vegetables. This decrease in pH can be attributed to the utilization of accumulated citric acid in the endocarp of cucumber. However, control cucumbers (uncoated) had greater pH decrease during storage as greater utilization of organic acids stored in the vacuoles as respiratory substrate (Medlicotte et al. 1987) compared to coatings which act as a protective layer around the food commodity which may result in less accumulation of acids inside the vacuoles. Hence, gradual decrease has been observed in coated cucumbers as compared to control cucumbers where guar gum in combination with cinnamon oil and commercial coatings showed better results in retention of pH among other coatings. The change in pH is associated with many reasons, it might be due to the effect of treatment, or changes in the biochemical conditions of the vegetable and slow rate of metabolic activity due to presence of coatings which in turn effectively delays the senescence (Adetunji et al. 2014). The values of titratable acidity of cucumber samples showed inverse behaviour to that of pH. Titratable acidity increases non-significantly, with storage time in both control and coated cucumbers (Figure 3b). Increase was little high in control samples while the coated (coating F, commercial coatings) samples slowed down the changes in acidity levels of cucumber. Since, loss of vegetable acidity has been associated with loss of quality during postharvest storage of vegetables, the retention of acidity contributed towards preserving the shelf-life of cucumber (Zapata et al. 2008). (Kinh et al. 2001) also reported that increase in titratable acidity of apple pulp during storage.

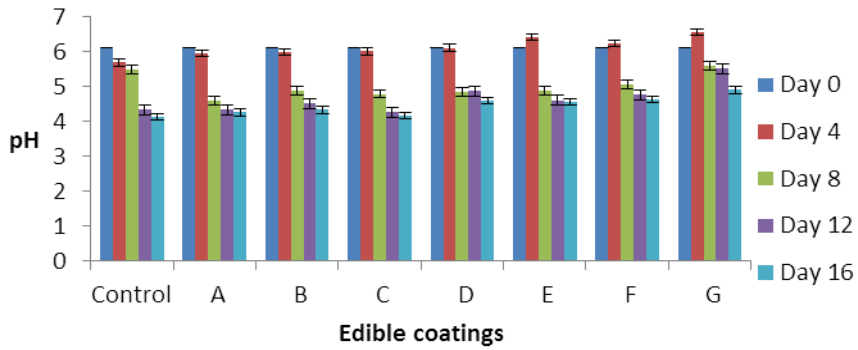

Figure 3a: pH in coated and uncoated cucumbers during storage at ambient conditions (25±2˚C, 70±5% R.H.) (where, Coating A: Carboxymethyl guar gum (1%)+potassium sorbate (0.4%)+glycerol (35%w/w)+tween-

80(0.1%), Coating B: Carboxymethyl guar gum(1%)+ cinnamon oil(0.1%)+glycerol+tween-80 (0.1%), Coating C: Carboxymethyl guar gum(1%)+ potassium sorbate (0.4%)+cinnamon oil (0.1%)+glycerol (35% w/w)+tween-80 (0.1%), Coating D: Guar gum(1%)+potassium sorbate (0.4%)+glycerol (35% w/w)+tween-80 (0.1%), Coating E: Guar gum (1%)+cinnamon oil (0.1%)+glycerol (35%)+tween-80 (0.1%), Coating F: Guar gum (1%)+ potassium sorbate (0.4%)+cinnamon oil (0.1%)+glycerol (35%)+tween-80 (0.1%), Coating G: Commercial coating, Control: Uncoated) [The vertical bar represents standard error of the means].

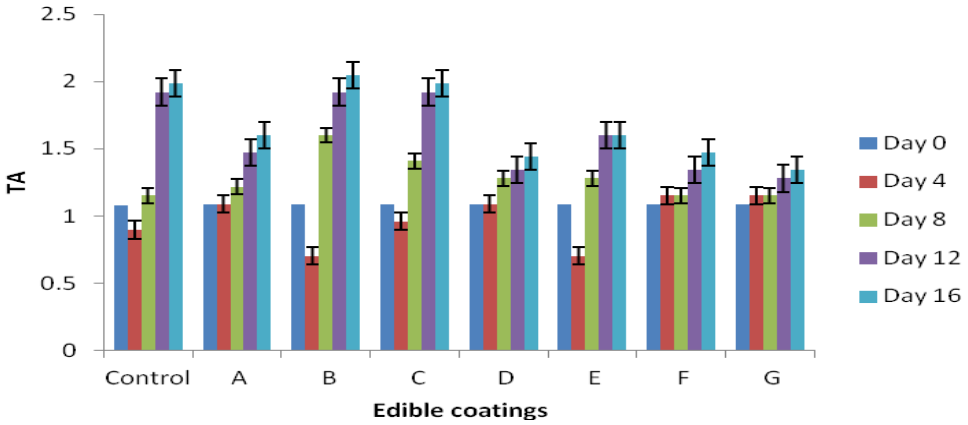

Figure 3b: Titratable acidity in coated and uncoated cucumber during storage at ambient conditions (25±2˚C, 70±5% R.H.) (where, Coating A: Carboxymethyl guar gum (1%)+potassium sorbate (0.4%)+glycerol (35%w/w)+tween-80(0.1%), Coating B: Carboxymethyl guar gum(1%)+ cinnamon oil(0.1%)+glycerol+tween-80 (0.1%), Coating C: Carboxymethyl guar gum(1%)+ potassium sorbate (0.4%)+cinnamon oil (0.1%)+glycerol (35% w/w)+tween-80 (0.1%), Coating D: Guar gum(1%)+potassium sorbate (0.4%)+glycerol (35% w/w)+tween-80 (0.1%), Coating E: Guar gum (1%)+cinnamon oil (0.1%)+glycerol (35%)+tween-80 (0.1%), Coating F: Guar gum (1%)+ potassium sorbate (0.4%)+cinnamon oil (0.1%)+glycerol (35%)+tween-80 (0.1%), Coating G: Commercial coating, Control: Uncoated) [The vertical bar represents standard error of the means].

Ascorbic acid content

Ascorbic acid content of both coated and uncoated (control) cucumbers initially increases and then decreases (Figure 4), however, the decrease was much slower in coated vegetables as compared to uncoated vegetables. The ascorbic acid contents found higher in coated cucumbers as compared to uncoated vegetables (pH<0.05) at the end of storage period. Higher ascorbic content in guar gum coated cucumbers might be due to slow ripening rate of guar gum coated cucumbers. Oxidation of organic acids may be caused due to many factors, such as exposure to oxygen, metals, light, pH changes, and temperature changes. Coatings served as a semipermeable layer which controls the exchange of oxygen and carbon dioxide (Bourtroom, 2008). These results were in agreement with (Adetunji et al. 2014) who also found the similar trend in chitosan and aloe-vera coated cucumbers. At low temperature storage, ascorbic acid reduction in vegetables is generally higher due to chilling injury (Tatsumi et al. 2006). Cardello et al. (1998) also observed reduction in ascorbic acid content of "Haden" mango when stored for 14 days.

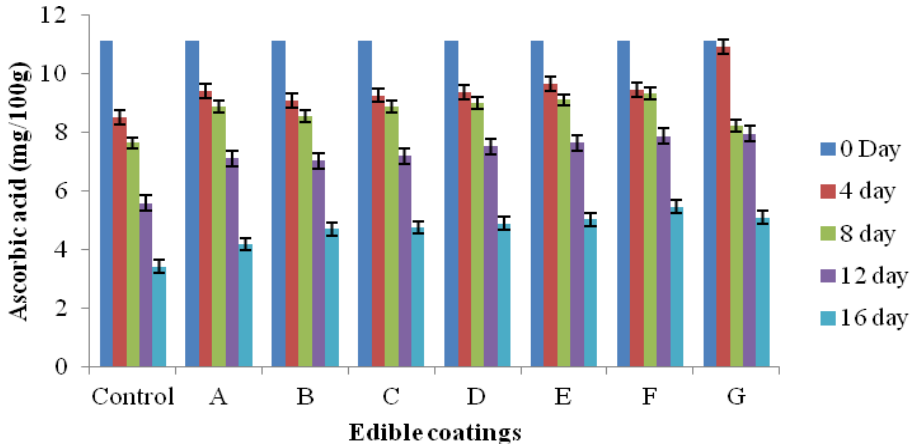

Figure 4: Ascorbic acid in coated and uncoated cucumbers during storage at ambient conditions (25±2˚C, 70±5% R.H.) (where, Coating A: Carboxymethyl guar gum (1%)+potassium sorbate (0.4%)+glycerol (35%w/w)+tween-80(0.1%), Coating B: Carboxymethyl guar gum(1%)+ cinnamon oil(0.1%)+glycerol+tween-80

(0.1%), Coating C: Carboxymethyl guar gum(1%)+ potassium sorbate (0.4%)+cinnamon oil (0.1%)+glycerol (35% w/w)+tween-80 (0.1%), Coating D: Guar gum(1%)+potassium sorbate (0.4%)+glycerol (35% w/w)+tween-80 (0.1%), Coating E: Guar gum (1%)+cinnamon oil (0.1%)+glycerol (35%)+tween-80 (0.1%), Coating F: Guar gum (1%)+ potassium sorbate (0.4%)+cinnamon oil (0.1%)+glycerol (35%)+tween-80 (0.1%), Coating G: Commercial coating, Control: Uncoated) [The vertical bar represents standard error of the means].

Total Soluble Solids (TSS)

Total soluble solids of cucumber found to be first increase and then decrease with increase in storage time in both coated and control cucumbers (Figure 5). However, the changes in TSS were not significant ($p \leq 0.05$). Coated cucumbers showed lesser variation in TSS than control (uncoated) cucumbers. With an increase in storage time, the starch converts into sugar in the tissues which indicates an increase in TSS (Bourtroom, 2008; Moalemiyan and Ramaswamy, 2012). Edible coating delays this process as coating slows down the metabolism by reducing internal respiration rate and thus, avoiding drastic reductions in the levels of soluble solids of coated vegetables as compared to control (uncoated) which implies changes in TSS in coated fruit was slower than control. A similar observation was also observed by Moalemiyan and Ramaswamy (2012) who observed increase in TSS up to 5-10 days and then decrease till the 15th day in cucumbers kept for storage. Kluge et al. (2002) suggested that the decrease in soluble solids may be due to oxidative decomposition of complex substances such as polysaccharides, sugars, organic acids, proteins, lipids present in fruits and vegetables into simple molecules and energy.

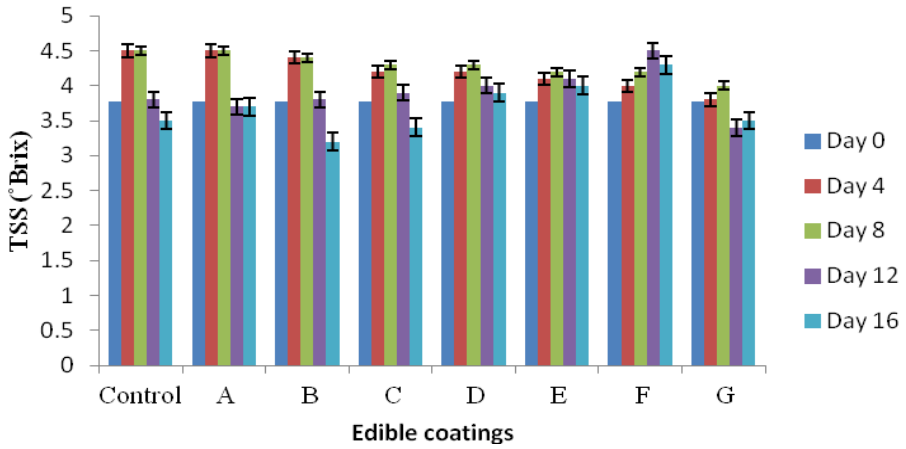

Figure 5: Total soluble solids (TSS) in coated and uncoated cucumbers during storage at ambient conditions (25±2˚C, 70±5% R.H.) (where, Coating A: Carboxymethyl guar gum (1%)+potassium sorbate (0.4%)+glycerol (35%w/w)+tween-80(0.1%), Coating B: Carboxymethyl guar gum(1%)+ cinnamon oil(0.1%)+glycerol+tween-80 (0.1%), Coating C: Carboxymethyl guar gum(1%)+ potassium sorbate (0.4%)+cinnamon oil (0.1%)+glycerol (35% w/w)+tween-80 (0.1%), Coating D: Guar gum(1%)+potassium sorbate (0.4%)+glycerol (35% w/w)+tween-80 (0.1%), Coating E: Guar gum (1%)+cinnamon oil (0.1%)+glycerol (35%)+tween-80 (0.1%), Coating F: Guar gum (1%)+ potassium sorbate (0.4%)+cinnamon oil (0.1%)+glycerol (35%)+tween-80 (0.1%), Coating G: Commercial coating, Control: Uncoated) [The vertical bar represents standard error of the means].

Juicability (Juice content)

With an increase in storage time, juicability (juice content) of cucumber decreases significantly ($p<0.05$) in both coated and uncoated cucumber vegetables as there was an increase in weight loss due to loss of water through transpiration process. However, the decrease was much less in coated cucumbers as compared to control cucumbers (Figure 6). Cucumber juice is a good source of minerals and vitamins. Decrease in juicability of vegetables affects the quality of cucumber vegetables. Delay in the decrease of juice content of coated cucumbers with storage time retains the quality of cucumber juice. Edible coating containing guar gum, cinnamon oil and potassium sorbate (coating F) shows the maximum juice content among all edible coatings at the end of storage period. There was 50% reduction in juice content in control (uncoated) cucumber vegetable as compared to coating E, F, and G. The difference in juicability of coated and control cucumber can be explained on the basis of semi-permeable barrier made by edible coatings against moisture loss on the surface of vegetable (Bourtroom, 2008).

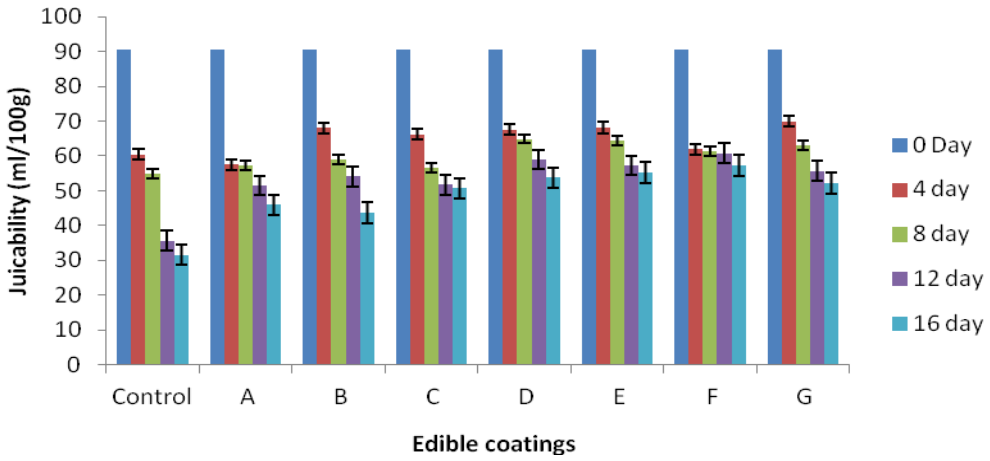

Figure 6: Juicability (Juice content) in coated and uncoated cucumbers during storage at ambient conditions (25±2˚C, 70±5% R.H.) (where, Coating A: Carboxymethyl guar gum (1%)+potassium sorbate (0.4%)+glycerol (35%w/w)+tween-80(0.1%), Coating B: Carboxymethyl guar gum(1%)+ cinnamon oil(0.1%)+glycerol+tween-80 (0.1%), Coating C: Carboxymethyl guar gum(1%)+ potassium sorbate (0.4%)+cinnamon oil (0.1%)+glycerol (35% w/w)+tween-80 (0.1%), Coating D: Guar gum(1%)+potassium sorbate (0.4%)+glycerol (35% w/w)+tween-80 (0.1%), Coating E: Guar gum (1%)+cinnamon oil (0.1%)+glycerol (35%)+tween-80 (0.1%), Coating F: Guar gum (1%)+ potassium sorbate (0.4%)+cinnamon oil (0.1%)+glycerol (35%)+tween-80 (0.1%), Coating G: Commercial coating, Control: Uncoated) [The vertical bar represents standard error of the means].

Total phenols

Folin-Ciocalteu phenol method was used to estimate total phenolic content (Table 1) at the end of storage period (Singleton et al. 1999). These values have been calculated by extrapolation of the standard curve of gallic acid (µg of gallic acid equivalents (GAE) per mg of dry weight of the sample extracts) obtained by linear equation (Figure 7):

Y= 0.0201x – 0.0113.

Total phenolic content decreases significantly ($p<0.05$) with the increase in storage period (Table 1). Phenolic compounds are found in the vegetable skin and it is associated with organoleptic and sensory qualities of vegetables, like its taste and astringency (Ferretti et al. 2010). Moreover, polyphenolic compounds like flavonoids, tannins, and phenolic acids are responsible for many biological activities in which one of them is antioxidant activity. Our study showed that at the end of the storage period, the total phenolic content (µg/mg of dry weight of sample) differed significantly ($p<0.5$) among the coated and uncoated cucumbers with the lowest value in the control (uncoated) cucumbers (6.84 ± 0.85) than in coating F (15.52 ± 0.56) and fresh vegetables (20.98 ± 0.35). During storage, coated vegetables exhibited relatively slower reduction in total phenolic content than uncoated (control) vegetables. Guar gum and carboxy-methyl guar gum treatment with cinnamon oil and potassium sorbate coating leads to better retention of total phenolic content during storage, hence retaining the quality of cucumber. Our study indicates that phenolic content changes were delayed by application of edible coating as coating forms a semi-permeable barrier around the surface of vegetable. Our results were also in agreement with (Petriccione et al. 2015) in sweet cherries coated by chitosan.

Table 1: Gallic acid equivalents (µg GAE/mg sample) at the end of storage period of cucumbers stored at ambient conditions (25±2˚C, 70±5% R.H.) (where, Coating A: Carboxymethyl guar gum (1%)+potassium sorbate (0.4%)+glycerol (35%w/w)+tween-80(0.1%), Coating B: Carboxymethyl guar gum(1%)+ cinnamon oil(0.1%)+glycerol+tween-80 (0.1%), Coating C: Carboxymethyl guar gum(1%)+ potassium sorbate (0.4%)+cinnamon oil (0.1%)+glycerol (35% w/w)+tween-80 (0.1%), Coating D: Guar gum(1%)+potassium sorbate (0.4%)+glycerol (35% w/w)+tween-80 (0.1%), Coating E: Guar gum (1%)+cinnamon oil (0.1%)+glycerol (35%)+tween-80 (0.1%), Coating F: Guar gum (1%)+ potassium sorbate (0.4%)+cinnamon oil (0.1%)+glycerol (35%)+tween-80 (0.1%), Coating G: Commercial coating, Control: Uncoated and each value = means ± standard error of the three replicates).

Sample	(µg GAE/mg sample)
Fresh cucumber	20.98 ± 0.35
Control (uncoated)	06.84 ± 0.85
Coating A	07.86 ± 0.55
Coating B	06.54 ± 0.50
Coating C	07.39 ± 0.79
Coating D	10.56 ± 0.99

Coating E	14.86 ± 0.89
Coating F	15.52 ± 0.56
Coating G	13.79 ± 0.56

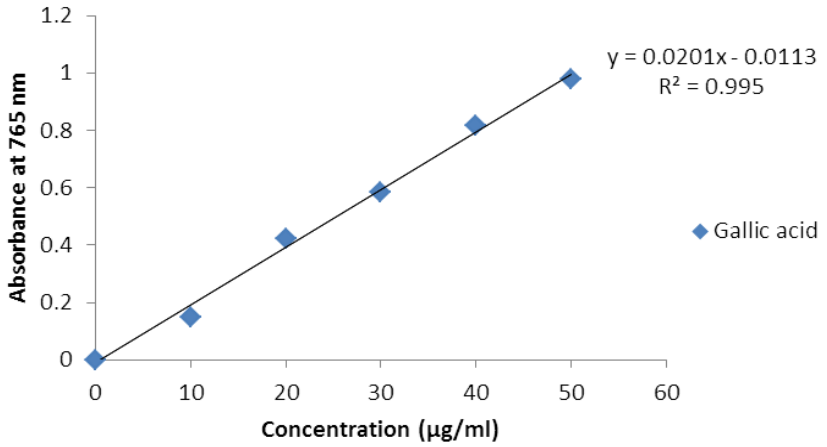

Figure 7: Standard curve of Gallic acid.

Antioxidant activity evaluation (DPPH Scavenging activity)

Antioxidants are the agents that can interfere with the process of oxidations such as reacting with free radicals, acting as oxygen scavengers etc. DPPH-radical scavenging activity refers to non-enzymatic antioxidant activity. DPPH (1,1-diphenyl-2-picryl-hydrazyl) free radical scavenging activity method is based on the ability of this stable free radical, DPPH to be decolorized (disappearance of purple colour) in the presence of antioxidants detected by spectrophotometer at 517 nm at different concentrations (Kumarasamy et al. 2007). According to the results (Figure 8), significant decrease ($p<0.05$) in antioxidant activity was found during storage period. It has been reported that the decrease in antioxidant activity is related to decrease in total phenolic content and ascorbic acid content during storage (Klimczak et al. 2007; Zhou et al. 2013). Among the various extracts of fresh, coated and uncoated cucumber, fresh cucumber extract exhibited the maximum activity (80%) at a concentration of 30mg/ml. Among the coated samples, better antioxidant, scavenging activity was shown by coating A, E, F (Guar gum containing, cinnamon essential oil) and coating G (commercial wax coating), remaining other coatings showed comparable results with that of uncoated samples (Figure 8). (Vieira et al. 2016) also reported that lower IC_{50} values of chitosan-aloe-vera coating that can preserve the antioxidant activity of blue berries. Similar results were observed by (Oriani et al. 2014) in apples where they have used cassava starch with cinnamon essential oil, they found that edible coating containing, cinnamon essential oil exhibited the highest antioxidant capacity when compared to other coatings. Ascorbic acid was used as the reference antioxidant. The antioxidant capacity of stored cucumber extracts was further evaluated by calculating IC_{50} values. Below figure 8 shows the scavenging activity of cucumbers.

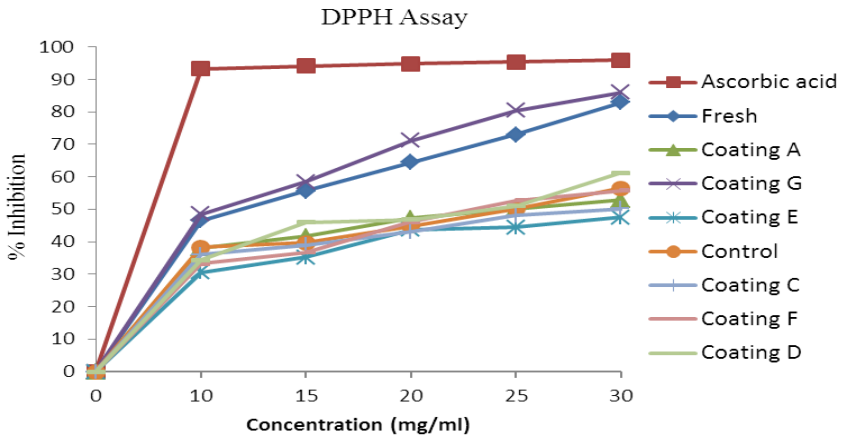

Figure 8: DPPH Scavenging activity of Fresh, coated and uncoated Cucumber vegetable extract (where, Coating A: Carboxymethyl guar gum (1%)+potassium sorbate (0.4%)+glycerol (35%w/w)+tween-80(0.1%), Coating B: Carboxymethyl guar gum(1%)+ cinnamon oil(0.1%)+glycerol+tween-80 (0.1%), Coating C: Carboxymethyl

guar gum(1%)+ potassium sorbate (0.4%)+cinnamon oil (0.1%)+glycerol (35% w/w)+tween-80 (0.1%), Coating D: Guar gum(1%)+potassium sorbate (0.4%)+glycerol (35% w/w)+tween-80 (0.1%), Coating E: Guar gum (1%)+cinnamon oil (0.1%)+glycerol (35%)+tween-80 (0.1%), Coating F: Guar gum (1%)+ potassium sorbate (0.4%)+cinnamon oil (0.1%)+glycerol (35%)+tween-80 (0.1%), Coating G: Commercial coating, Control: Uncoated).

IC_{50} values

(IC_{50}), also called Half maximal inhibitory concentration refers to quantity of particular drug or substance (here, cucumber extract) is needed to cause 50% inhibition of a given biological process (oxidation process). The antioxidant capacity is inversely proportional to IC_{50} values, which were calculated from the linear regression of the % antioxidant activity versus extract concentration (Qusti et al. 2010). IC_{50} values of fresh vegetable, coated and uncoated cucumber samples stored at 25 ºC obtained from DPPH antioxidant assay at the end of storage period was given in the Table 2. More the IC_{50} values, lesser will be its antioxidant potential. Fresh cucumber vegetable extract shows the best antioxidant potential followed by coating C, E, F and G which is relatively better as compared to control (uncoated vegetable) in retaining the antioxidant potential of cucumber extract.

Table 2: IC_{50} values of fresh vegetable and coated and uncoated cucumber at the end of storage period (where, Coating A: Carboxymethyl guar gum (1%)+potassium sorbate (0.4%)+glycerol (35%w/w)+tween-80(0.1%), Coating B: Carboxymethyl guar gum(1%)+ cinnamon oil(0.1%)+glycerol+tween-80 (0.1%), Coating C: Carboxymethyl guar gum(1%)+ potassium sorbate (0.4%)+cinnamon oil (0.1%)+glycerol (35% w/w)+tween-80 (0.1%), Coating D: Guar gum(1%)+potassium sorbate (0.4%)+glycerol (35% w/w)+tween-80 (0.1%), Coating E: Guar gum (1%)+cinnamon oil (0.1%)+glycerol (35%)+tween-80 (0.1%), Coating F: Guar gum (1%)+ potassium sorbate (0.4%)+cinnamon oil (0.1%)+glycerol (35%)+tween-80 (0.1%), Coating G: Commercial coating, Control: Uncoated and each value = means ± standard error of the three replicates).

Sample	DPPH IC_{50} values (mg/ml) of Fresh Weight
Fresh vegetable	14.05±0.005
Control (uncoated)	56.39±0.05
Coating A	24.06±0.04
Coating B	26.92±0.05
Coating C	22.03±0.08
Coating D	23.09±0.089
Coating E	20.15±0.09
Coating F	19.68±0.08
Coating G	19.72±0.07

Antibacterial activity

The antibacterial activity of an edible coating solution was observed against a wide variety of bacteria. The ability of an edible coating solution to inhibit growth of tests, microbial strains was measured on the basis of the diameter of zone of inhibition formed in the agar well diffusion test. If there was an absence of surrounding clear zone, then there was no inhibitory zone. The control (uncoated) cucumber showed no zone of inhibition hence does not have any inhibitory effect on tested strains of microorganism. Our results revealed that edible coating B, E, F showed clear zone of inhibition against known food borne bacteria: *S. aureus, P. aeruginosa, B. substilis, S. flexineri, B. cereus and E-coli (food pathogenic bacteria)* as compared to other tested coatings (Table 3). Incorporating antimicrobial agents like cinnamon essential oil into polysaccharide gum edible coatings improved the antimicrobial capacity of edible gum coatings which in-turn increases the shelf life of vegetables. The antimicrobial activities of essential oil were already reported by (Burt, 2004). The zone of inhibition found in coating B, C and coating E, F was similar to that found in chitosan edible coating which indicates the same efficiency of chitosan edible coating and coating B, C, E, F. Velasquez et al. (2014) reported that pectin based edible coating containing essential oil reduced the decay of coated vegetable stored at ambient conditions and extended its shelf life (Velasquez et al. 2014). Oriani et al. (2014) also observed that cassava starch containing; cinnamon essential oil restricts the growth of *S. aureus* and *Salmonella* on the minimally processed apples.

Table 3: Antibacterial activity (zone of inhibition) against given bacterial strains tested by agar well diffusion assay method of various edible coatings used in the study (where symbol - in boxes represents no zone of inhibition; Coating A: Carboxymethyl guar gum (1%)+potassium sorbate (0.4%)+glycerol (35%w/w)+tween 80 (0.1%), Coating B: Carboxymethyl guar gum(1%)+ cinnamon oil(0.1%)+glycerol+tween80 (0.1%), Coating C: Carboxymethyl guar gum(1%)+ potassium sorbate (0.4%)+cinnamon oil (0.1%)+glycerol (35% w/w)+tween-80 (0.1%), Coating D: Guar gum(1%)+potassium sorbate (0.4%)+glycerol (35% w/w)+tween-80 (0.1%), Coating E: Guar gum (1%)+cinnamon oil (0.1%)+glycerol (35%)+tween-80 (0.1%), Coating F: Guar gum (1%)+ potassium sorbate (0.4%)+cinnamon oil (0.1%)+glycerol (35%)+tween-80 (0.1%), Coating G: Commercial coating, Control: Uncoated and each value = means ± standard error of the three replicates)

Bacterial strains	**Diameter of zone of Inhibition (mm)**							
Gram positive	**Coating A**	**Coating B**	**Coating C**	**Coating D**	**Coating E**	**Coating F**	**Coating G**	**Control (uncoated)**
S. aureus	-	11.0±0.0	10.0±0.12	-	-	12.1±0.56	-	-
S. pyrogene	-	-	-	-	-	-	-	-
B. cereus	-	-	12.0±0.34	-	18.0±0.12	18.7±0.0	-	-
B. substilis	-	13.0±0.10	14.5±0.10	-	12.3±0.56	15.2±0.49	-	-
S. epidermis	-	10.0±0.23	14.0±0.33	-	15.1±0.0	16.0±0.27	-	-
Gram negative								
E.coli	-	-	11.0±0.29	-	-	15.0±0.50	-	-
S. flexineri	-	12.5±0.25	14.4±0.19	-	22.0±0.24	25.0±0.25	-	-
S. enteric	-	-	-	-	-	-	-	-
P. mirabilis	-	-	-	-	12.2±0.12	13.3±0.00	-	-

CONCLUSION

Various edible coatings used in our research study were effective in reducing weight loss, colour changes and control of psychotropic microorganisms and maintaining quality during storage. The presence of guar gum resulted in less moisture loss and better firmness of cucumber. Our study demonstrated that cucumber coated with guar-gum and carboxy-methyl guar gum containing cinnamon oil and potassium sorbate showed a significant delay in the change of weight, pH, titratable acidity, and soluble solids concentration during storage at 25ºC as compared to control (uncoated) vegetable. The coatings helped in retaining the phenolic compounds and prevented excess oxidation by showing good antioxidant activity which was comparable to that of fresh vegetable. These edible coatings containing essential oil reduced microbial contamination by having antimicrobial activity against a number of food borne bacteria, however, the antimicrobial activity can be enhanced by increasing the concentration of essential oil in edible coating composition, but the increase in concentration should be optimized in such a way that it should not affect the sensory properties of fresh commodity as essential oil has a characteristic aroma due to the presence of phenols. At this moment, most studies on edible coating have been conducted at a laboratory scale. Therefore, further research is required on an industrial scale so that more fruits and vegetables can be preserved by edible coatings on a large scale commercially.

ACKNOWLEDGEMENT

The authors are very grateful to Guru Gobind Singh Indraprastha University, Delhi, India for providing the University Research Fellowship and necessary facilities for carrying out this work.

REFERENCES

1. Anand T, Chandrasekaran A, Kuttalam SP, Senthilraja G, Raguchander T, Samiyappan R. Effectiveness of Azoxystrobin in the control of *Erysiphe Cichoracearum* and *Pseudoperonospora Cubensis* on cucumber. J Plant Prot Res, 2008; 48(2): 147-159.
2. Kasim MU, Kasim R. Vapor heat treatment increase quality and prevent chilling injury of cucumbers (*Cucumis melo* L. cv. Silor). American-Eurasian J Agric Env Sci, 2011; 11(2): 269-274.
3. Wang CY, Qi L. Modified atmosphere packaging alleviates chilling injury in cucumbers. Postharvest Biol Technol, 1997; 10: 195-200.
4. Vargas M, Pastor C, Chiralt A, Mc Clements DJ, Martinez CG. Recent advances in edible coatings for fresh and minimally processed vegetables. Crit Rev Food Sci Nutr, 2008; 48: 496-511.
5. Bourtroom T. Edible films and coatings: characteristics and properties. Int Food Res J, 2008; 15(3): 237-248.
6. Hagenmaier RD, Shaw PE. Gas permeability of vegetable coating waxes. J Am Soc Hortic Sci, 1992; 117(1): 105-109.
7. Burt S. Essential oils: their antibacterial properties and potential applications in foods-A review. Int J Food Microbiol, 2004; 94: 223-253.
8. Velasquez MA, Passaro CP, Lara-Guzman OJ, Alvarez R, Londono J. Effect of an edible fungistatic coating on the quality of the 'Valencia' orange during storage and marketing. Acta Hort, 2014; 1016: 163-169.
9. Castillo S, Pérez-Alfonso CO, Martínez-Romero D, Guillén F, Serrano M, Valero D. The essential oils thymol and carvacrol applied in the packing lines

avoid lemon spoilage and maintain quality during storage. Food Cont, 2014; 35: 132-136.
10. Palou L, Valencia-Chamorro SA, Pérez-Gago MB. Antifungal edible coating for fresh vegetables: a review. Coatings, 2015; 5: 962-986.
11. Lens-Lisbonne C, Cremieux A, Maillard C, Balansard G. Methodes d'evaluation de l'activite´ antibacterienne des huiles essentielles: application aux essences de thym et de cannelle. Journal de Pharmacie de Belgique, 1987; 42(5): 297-302.
12. Chen S, Nussinovitch A. Permeability and roughness determinations of wax-hydrocolloid coatings, and their limitations in determining citrus vegetable overall quality. Food hydrocoll, 2001; 15: 127-137.
13. Mehyar GF, Al-Qadiri HM, Abu-Blan H, Swanson B. Antifungal effectiveness of potassium sorbate incorporated in edible coatings against spoilage moulds of apples, cucumber and tomatoes during refrigerated storage. J Food Sci, 2011; 67(3): 210-217.
14. Mehyar GF, Al-Qadiri HM, Swanson BG. Edible coatings and retention of potassium sorbate on apples, tomatoes and cucumbers to improve antifungal activity during refrigerated storage. J Food Process Preserv, 2014; 38: 175-182.
15. Srichamroen A. Inference of temperature and salt on viscosity property of guar gum. Naresuan Univ, 2007; 15(2): 55-62.
16. Saha A, Gupta RK, Sharma RR, Kumar K, Tyagi YK. Edible coating and its effect on the quality and shelf life of 'Hachiya', an astringent variety of persimmon. Asian J Biochem Pharmaceutical Res, 2015; 5(3): 2231-2560.
17. Ghosh A, Dey K, Bhowmick N, Medda PS, Dutta P. Effect of guar gum as edible coatings. *The Ecoscan*, 2014; 6: 202-207.
18. Pal S. Carboxymethyl guar: its synthesis and macromolecular characterization. J App Poly Sci, 2009; 111(5): 2630-2636.
19. Gong H, Mingzhu L, Chen J, Han F, Gao C, Zhang B. Synthesis and characterization of carboxymethyl guar gum and rheological properties of its solutions. Carbohydr polym, 2012; 88(3): 1015-1022.
20. Hasan SMK, Sarker MSH, NicolaİŠ B. The effect of Bio-FreshTM edible coatings on shelf life and quality of pears. Int J Agr Sci Res, 2013; 2: 74-82.
21. El-Anany AM, Hassan GFA, Rehab Ali FM. Effects of edible coatings on the shelf life and quality of Anna apple (*Malus domestica Borkh*) during cold storage. J Food Tech, 2009; 7: 5-11.
22. AOAC (Association of Official Analytical Chemists). Official methods of analysis of AOAC International. 16th Ed. Virginia, (2000) USA.
23. Cliffe S, Fawer MS, Maier G, Takata K, Ritter G. Enzyme assays for the phenolic content of natural juices. J Agric Food Chem, 1994; 42: 1824-1828.
24. Shen Q, Zhang B, Xu R, Wang Y, Ding X, Li P. Antioxidant activity in-vitro of selenium-contained protein from the se-enriched *Bifido bacteriumanimalis* 01. *Anaerobe*, 2010; 16(4): 380-386.
25. Zhu X, Wang QM, Cao JK, Jiang WB. Effects of chitosan coating on postharvest quality of mango (*Mangifera indica* L. CV. Tainong) vegetables. J Food Process Preserv, 2008; 32(5): 770-784.
26. Dong H, Cheng L, Tan J, Zheng K & Jiang Y. Effect of chitosan coating on quality and shelf-life of peeled litchi vegetable. J Food Eng, 2004; 64(3): 355-358.
27. Oluwaseun AC, Kayode AA, Bolajoko FO, Bunmi AJ, Olagbaju AR. Effect of edible coatings of carboxy methyl cellulose and corn starch on cucumber stored at ambient temperature. Asian J Agric Biol, 2013; 1(3): 133-140.
28. Adetunji CO, Fadiji AE, Aboyeji OO. Effect of chitosan combined aloe vera gel on cucumber (*Cucumis sativa* L.) postharvest quality during ambient storage. J Emerg Trends Eng basic Sciences, 2014; 5(6): 391-397.
29. Marpudi SL, Abirami LSS, Pushkala R, Srividya N. Enhancement of storage life and quality maintenance of papaya vegetables using aloe vera based antimicrobial coatings. Ind J Biotech, 2011; 10: 83-89.
30. Oriani VB, Molina G, Chiumarelli M, Pastore GM, Hubinger MD. Properties of cassava starch-based edible coating containing essential oils. J Food Sci, 2014; 79(2): 189-194.
31. Patrícia S, Tanada-Palmu, Carlos RF, Grosso. Effect of edible wheat gluten-based films and coatings on refrigerated strawberry (*Fragaria ananassa*) quality. Postharvest Biol Technol, 2005; 36: 199-208.
32. Medlicotte AP, Sigrist JM, Reynolds SB, Thompson AK. Effect of ethylene and acetylene on mango vegetable ripening. J Applied Biol, 1987; 111: 439-444.
33. Zapata PJ, Guillén F, Martínez-Romero D, Castillo S, Valero D, Serrano M. Use of alginate or zein as edible coatings to delay postharvest ripening process and to maintain tomato (*Solanum lycopersicon* M.) quality. J Sci Food Agric, 2008; 88: 1287-1293.
34. Kinh SAEH, Dunne CP, Hoover DG. Preparation and preservation of apple pulp with chemical preservatives and mild heat. J Food Prot, 2001; 28(6): 111-114.
35. Tatsumi Y, Isogai M, Sei S, Srilong V. Changes in ascorbic acid content and ascorbate metabolism related enzyme activities during storage in cucumber (*Cucumis sativus* L.) and Balsam pear (*Momordica Charantia* L.) Acta Hortic, 2006; 712: 755-762.
36. Cardello HMAB, Cardello L. Content of vitamin C, ascorbate oxidase activity and sensory sleeve profile *(Magnifera indica* L.) Var. Haden, during ripening. Ciência e Tecnologia de Alimentos, 1998; 18(2): 211-217.
37. Kluge RA, Nachtigal JC, Fachinello JC, Bilhalva AB. Physiology and postharvest handling vegetables of temperate. 2nd Ed., London: Rural; 2002, pp. 95-115.

38. Singleton VL, Orthofer R, Lamuela-Raventos RM. Analysis of total phenols and other oxidation substrates and antioxidants by means of Folin-Ciocalteu reagent. Method Enzymol, 1999; 299: 152-178.
39. Ferretti G, Bacchetti T, Belleggia A, Neri D. Cherry antioxidants: from farm to table, Molecules, 2010; 15: 6993-7005.
40. Petriccione M, Sanctis FD, Pasquariello MS, Mastrobuoni F, Rega P, Scortichini M, Menacarelli F. The effect of chitosan coating on the quality and neutraceutical traits of sweet cherry during postharvest life. Food Bioprocess Technol, 2015; 8: 394-408.
41. Kumarasamy Y, Byres M, Cox PJ, Jaspars M, Nahar L, Sarker SD. Screening seeds of some scottish plants for free-radical scavenging activity. Phytotherapy Res, 2007; 2(7): 615-621.
42. Klimczak I, Matecka M, Szlachta M, Gliszczynska-Swiglo A. Effect of storage on the content of polyphenols, Vitamin C and the antioxidant activity of orange juices, J Food Compost Anal, 2007; 20: 313-22.
43. Zhou CL, Liu W, Zhao J, Yuan C, Song Y, Chen D, Ni YY, Li QH. The effect of high hydrostatic pressure on the microbiological quality and physicochemical characteristics of pumpkin (Cucurbita maxima Duch.). Innov Food Sci Emerg Technol, 2013; 21: 24-34.
44. Vieira JM, Flores-López ML, Rodríguez DJ, Sousa MC, Vicente AA, Martins JT Effect of chitosan-aloe vera coatings on postharvest quality of blueberry (Vaccinium corymbosum) vegetable. Postharvest Biol Technol, 2016; 116: 88-97.
45. Qusti SY, Ahmed N, Abo-khatwa Bin Lahwa, MA. Screening of antioxidant activity and phenolic content of selected food items cited in the Holly Quran. EJBS, 2010; 2(1): 40-51.