ABSTRACT
A study was conducted to find the effect of composite edible coating on the physicochemical properties of tomatoes stored at ambient conditions. The parameters evaluated were titratable acidity, pH, vitamin C content, TSS and total and reducing sugars. The effect of coating was found statistically significant for all parameters except pH for coated samples as compared to control sample. The effect of storage period was also evaluated for same parameters and it was observed that the storage period affects significantly on quality parameters of tomatoes.

KEYWORDS Edible coating; tomatoes; SPI; CMC; Ambient Conditions.

1. INTRODUCTION
Edible coatings have long been known to protect perishable food products from deterioration by retarding dehydration, suppressing respiration, improving textural quality, helping retain volatile flavor compounds and reducing microbial growth (Debeaufort, F., Quezada-Gallo, J.A.& Voilley, A. 1998). Edible films and coatings afford numerous advantages over conventional non-edible polymeric packaging. They can reduce the complexity of the food package and, even if they are not consumed with the packaged product, can contribute to the reduction of environmental pollution by virtue of their biodegradable nature. In recent years, the potential of edible films to control water transfer, and to improve food quality and shelf-life, has received increasing attention from researchers and industry (Garcia, Martino, & Zaritzky, 1998; Kamper & Fennema, 1985; Rico-Pena & Torres, 1990; Yaman & Bayoindirli, 2002). Edible coatings can provide an alternative to extend the postharvest life of fresh fruits and vegetables and can also result in the same effect as modified atmosphere storage where the internal gas composition is adjusted (Park, 1999).

Traditionally, films and coatings have been used to reduce water loss, but new film materials and edible coatings formulated with a wider range of permeability characteristics facilitate achieving a “modified atmosphere” effect in fresh fruits. Edible films and coatings are generally produced using biological materials such as proteins, lipids and polysaccharides. Films made of polysaccharides or proteins usually have suitable mechanical and gas barrier properties but show high permeability to moisture and poor water vapor barrier properties. In contrast, films composed of lipids (waxes or other lipids) exhibit good water vapor barrier properties but show poor mechanical resistance and high oxygen permeability. When such ingredients are combined, they could physically and/or chemically interact and may result in films or coatings with improved properties (Diab, T., Biliaderis, C. G., Gerasopoulos, D., & Stakiotakis, E. 2001). Surface coatings can decrease fruit peel permeance, modify the internal atmosphere, reduce water loss, and reduce fruit respiration rate. In coating materials, mixtures of lipids, proteins, carbohydrates, plasticizers, surfactants, and additives are used dispersed in different kinds of solvents such as water or alcohols. Combining these materials in different ways provides the coating systems with a wide range of functional property values: barrier, appearance, mechanical, etc. Coating fruits with an edible film is an effective storage method at room temperature. Edible films have been proven to be an effective preservation technique that can not only keep fruit plumpness, fresh appearance and hardness but also improve the luster of fruits’ surface thereby increasing the commercial value of fruits.

Although the use of films and edible coatings in food quality preservation is not a recent concept, researches in this field have recently been intensified. The factors that contribute to the renewed interest include the consumer’s demand for high quality food, environmental concerns in relation to the accumulation of non-biodegradable packaging and opportunities to create new markets for the production of films from renewable resources (Gennadios, A., Hanna, M. A., & Kurth, L. B. 1997; Rosa, D. S., Franco, B. L. M., & Calil, M. R. 2001). Edibility, biodegradability and increased food safety are the main benefits of active edible films. Their environmental friendly aspects make them alternatives in packaging systems, without the ecological costs of the synthetic non-biodegradable materials. In the future, they will be able to replace partially or totally conventional synthetic packaging. (Krochta & Mulder-Johnston, 1997). Present study was conducted to find the effect of composite edible coating on the physicochemical properties of tomatoes stored at ambient conditions.

2. MATERIALS AND METHODS
Soy Protein Isolate (90% protein) used in the experiment was purchased commercially. Glycerol (LR grade) used as plasticizer and Carboxymethyl Cellulose, Oleic Acid, Sodium Benzoate and Ascorbic Acid were purchased from local chemical supplier. Sodium Hydroxide (LR grade) used for pH
adjustment was also purchased from S.D. Fine Chemicals Pvt. Ltd. The tomato sample used in study were purchased from local market and graded as per equal maturity level.

2.1 Coating Solution Preparation and Application

Soy protein isolate, Carboxymethyl Cellulose and Oleic acid in predetermined quantities were dispersed in 100 ml distilled water (DW), glycerol (3.2 gm) was added as plasticizer followed by pH adjustment with 1N Sodium Hydroxide solution to 8. The other components like ascorbic acid and Sodium Benzoate were also added as per the formulations shown in Table 1 and coded as A, B and C. The solutions were then heated with constant stirring on heating mantle at 80-85°C temperature for 15 min. Tomatoes were dipped in different coating solutions for 30s, the excess coating was drained and the coated tomatoes were kept for surface drying under natural convection for 12±2 hrs. Tomatoes dipped in distilled water were used as a control. After the coating process, tomatoes were stored at ambient conditions at a temperature of 35 ± 3 deg Celsius and RH of 70 ± 5 per cent for 9 days. For each treatment 20 samples were coated and three replications per treatment were analyzed after 1, 3, 5, 7 and 9 days of storage.

Table 1: Formulation of Edible Coatings for Tomatoes

<table>
<thead>
<tr>
<th>Coating Treatment</th>
<th>Soy Protein Isolate (%)</th>
<th>Carboxymethyl Cellulose (%)</th>
<th>Oleic Acid (%)</th>
<th>Sodium Benzoate (%)</th>
<th>Ascorbic Acid (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4</td>
<td>0.2</td>
<td>1</td>
<td>-----</td>
<td>-----</td>
</tr>
<tr>
<td>B</td>
<td>4</td>
<td>0.2</td>
<td>1</td>
<td>0.1</td>
<td>-----</td>
</tr>
<tr>
<td>C</td>
<td>4</td>
<td>0.2</td>
<td>1</td>
<td>-----</td>
<td>0.4</td>
</tr>
<tr>
<td>Control</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
<td>-----</td>
</tr>
</tbody>
</table>

2.2 Titratable Acidity

Titratable acidity was determined using 10 g aliquots of fruit puree in 90 ml of distilled water and titrated with 0.1N NaOH to an end-point of pH 8.1. Titratable acidity was expressed as percentage of citric acid (AOAC, 2000).

2.3 Vitamin C

Vitamin C (ascorbic acid) content was determined by using titrimetric method with the titration of filtrate against 2, 6- dichlorophenol indophenol and the results of vitamin C content were expressed as mg/100 g (AOAC, 2000)

Ascorbic acid content (mg per 100g of fruit pulp) = \( \frac{\text{TxDxV}}{\text{x100}} \)

Where,

T = Titre,
D = Dye factor,
V1 = Volume made up,
V2 = Volume of extract taken for estimation
W = Weight of sample taken for estimation.

2.4 pH and TSS

The pH of the sample was determined by the method described by Ranganna 1979. The pH of tomato juice recorded by using an electronic pH meter. The pH meter was standardized with the help of buffer solution. The Total Soluble Solid (TSS) content of tomato fruit pulp was determined by using Hand refractometer by placing a drop of pulp solution on its prism. The percentage of TSS was obtained from direct reading of the refractometer. Temperature correction was made by using methods described by Ranganna 1979.

2.5 Total and Reducing Sugars

The reducing and non-reducing sugar contents were determined by following the Shaffer-Somogyi method as described by Ranganna.

2.6 Statistical Analysis

Analysis of variance (ANOVA) was used to detect treatment effect. Mean separation was performed by using least significance difference (LSD) at the p<0.05 level.

3. RESULT AND DISCUSSION

3.1 pH, Titratable Acidity and Vit C Content

As it is observed from Table 2 the effect of coating treatments on pH value is statistically insignificant (p<0.05). The possible reason for that could be that all tomatoes selected for the experiment had same maturity level and another reason may be different micro modified atmosphere created by different treatments. However, small difference in average pH value of control i.e. 4.74 and coated samples A, B and C with values of 4.68, 4.68 and 4.62 respectively was recorded. All these treatments exhibited comparatively lower pH as compared to that of the fruits of control set i.e. uncoated.

Table 2: Effect of Treatments on pH, Acidity and Vit C Content in Tomatoes at Ambient Conditions

<table>
<thead>
<tr>
<th>Treatments</th>
<th>pH</th>
<th>% Acidity</th>
<th>Vit C Content (mg/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>4.68</td>
<td>0.455(^b)</td>
<td>35.23(^a)</td>
</tr>
<tr>
<td>B</td>
<td>4.68</td>
<td>0.465(^b)</td>
<td>35.25(^b)</td>
</tr>
<tr>
<td>C</td>
<td>4.62</td>
<td>0.456(^b)</td>
<td>47.02(^a)</td>
</tr>
<tr>
<td>Control</td>
<td>4.74</td>
<td>0.345(^b)</td>
<td>34.90(^b)</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>ns*</td>
<td>0.067</td>
<td>3.314</td>
</tr>
</tbody>
</table>

Means followed by same alphabet in a column do not differ significantly

There was a significant change (p<0.05) in average titratable acidity of the uncoated samples (Fig.1) as compared to coated samples of tomatoes at ambient conditions. Among various treatments the samples treated with coating A, B and C have got statistically significant change in average titratable acidity values as compared to control sample. The lowest average acidity value of 0.345% was shown by control sample followed by sample A, C and B with average acidity values of 0.455, 0.456 and 0.465% (Table 2). Though, there is statistically significant difference in average acidity values of coated and uncoated samples, there is no significant difference within coated samples. Thus the effect of coating is more pronounced in keeping higher average acidity values of tomato samples than the coated sample and it can be mentioned that treatment B was best among all.
other treatments as far as acidity of tomato sample is concerned. The vitamin C content of samples with treatment C was significantly higher as compared to other samples including control (Table 3). The highest average vitamin C value of 47.02 mg/100g was found for samples of treatment C followed by treatment B, C and control with values of 35.25, 35.23 and 34.9 mg/100g respectively (Table 2). The reason for higher vitamin C values in samples of treatment C is external addition of vitamin C to the edible coating where it is expected that edible coating can function as a carrier of nutrients.

The effect of storage days on pH value of tomatoes stored at ambient conditions was statistically significant. The pH value go on increasing with storage period with maximum average value of 4.8 as compared to average value of 4.6 on 1st day of storage (Table 3). The changes in pH might be due to • the variations in titratable acidity which may be attributed to increased activity of citric acid glyoxylase during ripening.

• reduction in acid content may be due to their conversion into sugars and further utilization in metabolic process during storage.

The equations to show the effect of storage period (x) on pH (y) for sample A, B, C and Control are given as follows

- 0.0443x^2 + 0.1657x + 4.34  (R^2 = 0.9832)
- 0.0071x^2 + 0.0071x + 4.58  (R^2 = 0.9184)
- 0.0357x^2 - 0.2043x + 4.84  (R^2 = 0.6735)
- 0.0071x^2 + 0.0271x + 4.58  (R^2 = 0.9560)

The effect of storage days on acidity of tomatoes was found significantly different. It is observed that there is significant difference in average acidity values of tomatoes stored upto 9 days (Table 3).

### Table 3: Effect of Storage Days on pH, Acidity and Vit C Content in Tomatoes at Ambient Conditions

<table>
<thead>
<tr>
<th>Days</th>
<th>pH</th>
<th>% Acidity</th>
<th>Vit C Content (mg/100g)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4.6b</td>
<td>0.551b</td>
<td>51.14b</td>
</tr>
<tr>
<td>3</td>
<td>4.6b</td>
<td>0.475bc</td>
<td>46.98b</td>
</tr>
<tr>
<td>5</td>
<td>4.6b</td>
<td>0.405cd</td>
<td>38.45c</td>
</tr>
<tr>
<td>7</td>
<td>4.6b</td>
<td>0.380df</td>
<td>28.87e</td>
</tr>
<tr>
<td>9</td>
<td>4.8c</td>
<td>0.339ge</td>
<td>21.68f</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>0.108</td>
<td>0.075</td>
<td>3.705</td>
</tr>
</tbody>
</table>

Means followed by same alphabet in a column do not differ significantly.

There is no significant difference between tomatoes stored at 3 and 5 days, 5 and 7 days, 5 and 9 and 7and 9 days. The maximum average acidity value of 0.552% was observed on 1st day of storage and lowest of 0.339% on 9th day of storage. Bhattarai and Gautam (2006) also reported that during storage the fruit itself might utilize the acids therefore, during storage period acid content in fruit decreases. The equations to show the effect of storage period (x) on acidity (y) for sample A, B, C and Control are given as follows

- 0.0066x^2 - 0.0788x + 0.6196  (R^2 = 0.9781)

### 3.2 TSS, Total and Reducing Sugars

Total soluble solids (ºBrix) of control and treated tomato fruits showed that there is significant difference (Fig 2). The effect of coating treatments on TSS of Tomatoes is statistically significant as compared to control (Table 4). The highest average TSS value was shown by control sample i.e. 5.70 ºBrix followed by samples treated with coating C, B and A showing the average values of 5.48, 5.42 and 5.30 ºBrix. Among coating treatments the TSS values were statistically insignificant between A and B, and B and C. The reduction in the TSS of treated tomato fruit was probably due to slowing down of respiration and metabolic activity. In this regard the view of Rohani et al (1997), is noteworthy that the slower respiration also slows the synthesis and use of metabolites resulting in lower TSS of coated samples due to the slower change from carbohydrates to sugars. Total sugar percentage is an important factor for determining the quality of the tomato fruits. The flavour of a product depends on total sugar percentage. The effect of edible coating treatments on total sugars of tomatoes stored at ambient conditions found to be significant (p<0.05). The uncoated sample found to have significantly higher total sugar values as compared to coated samples (Fig 2). The average Total sugar value was observed in control sample i.e. 4.53% followed by samples coated with coating C, B and A with values of 3.45, 3.22 and 3.10% respectively (Table 4). The reason for higher total sugar content in uncoated sample may be decreased rate of respiration in coated samples where the utilization of sugar as a respiratory substrate also decreased. Similar results for tomatoes were also reported by Shelia Sammi and Tariq Masud (2007). The effect of various edible coatings on reducing sugar content of tomatoes at ambient conditions was significant as compared to control (Fig 2).
Fig 1 Changes in pH, Acidity and Vitamin C Content of Tomatoes with Storage Period at Ambient Conditions.
Fig 2 Changes in Total Soluble Solids, Total and Reducing Sugars of Tomatoes with Storage Period at Ambient Conditions

Table: 4 Effect of Treatments on Total Soluble Solids, Total and Reducing Sugars in Tomatoes at Ambient Conditions

<table>
<thead>
<tr>
<th>Treatments</th>
<th>TSS(°Brix)</th>
<th>% Total Sugars</th>
<th>% Reducing Sugars</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>5.30</td>
<td>3.10</td>
<td>2.21</td>
</tr>
<tr>
<td>B</td>
<td>5.42</td>
<td>3.22</td>
<td>2.23</td>
</tr>
<tr>
<td>C</td>
<td>5.48</td>
<td>3.45</td>
<td>2.54</td>
</tr>
<tr>
<td>Control</td>
<td>5.70</td>
<td>4.53</td>
<td>2.77</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>0.155</td>
<td>0.416</td>
<td>0.132</td>
</tr>
</tbody>
</table>

Means followed by same alphabet in a column do not differ significantly
The highest value of reducing sugar was found in control i.e. 2.57 per cent followed by sample treated with coating C, B, and A and the values are 2.44, 2.25 and 2.21 respectively (Table 4). There was statistically insignificant difference in reducing sugar content of samples with coating A and B, similarly it is insignificant in C and control. The significant changes in the TSS values of tomato fruits during their post harvest storage at ambient conditions are presented in Fig 2.

<p>| Table: 5 Effect of Storage Days on Total Soluble Solids Total and Reducing Sugars in Tomatoes at Ambient Conditions |</p>
<table>
<thead>
<tr>
<th>Days</th>
<th>TSS (°Brix)</th>
<th>% Total Solids</th>
<th>% Reducing Sugars</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>5.15abc</td>
<td>3.02a</td>
<td>2.09ab</td>
</tr>
<tr>
<td>3</td>
<td>5.30abc</td>
<td>3.41a</td>
<td>2.28b</td>
</tr>
<tr>
<td>5</td>
<td>5.47a</td>
<td>3.73a</td>
<td>2.46ab</td>
</tr>
<tr>
<td>7</td>
<td>5.62c</td>
<td>3.94d</td>
<td>2.57a</td>
</tr>
<tr>
<td>9</td>
<td>5.82d</td>
<td>3.79a</td>
<td>2.44cd</td>
</tr>
<tr>
<td>LSD (0.05)</td>
<td>0.173</td>
<td>0.466</td>
<td>0.147</td>
</tr>
</tbody>
</table>

Means followed by same alphabet in a column do not differ significantly.

From Table 5 it is revealed that there is significant difference in each day of storage except 1st and 3rd day. The average TSS values goes on increasing with the storage days and highest TSS value of 5.82 was observed on 9th day of storage.

Changes in TSS contents were natural phenomenon occurred during ripening and is correlated with hydrolytic changes in starch concentration during ripening in post harvest period. In tomatoes, conversion of starch to sugar is an important index of ripening (Kays, 1997). The equations to show the effect of storage period (x) on TSS (y) for sample A, B, C and Control are given as follows:

\( y = -0.0519x^2 + 0.4262x + 2.4003 \) (R\(^2\) = 0.8900)

\( y = -0.1384x^2 + 0.8665x + 2.1519 \) (R\(^2\) = 0.9240)

\( y = -0.0164x^2 + 0.37x + 2.5256 \) (R\(^2\) = 0.9045)

\( y = -0.1349x^2 + 1.222x + 2.3542 \) (R\(^2\) = 0.9924)

The highest average total and reducing sugar content of 3.94 and 2.57 per cent respectively was found on 7th day of storage (Table 5) which can be considered as optimum storage period for tomatoes as far as sugars or metabolic substrates are concerned. The increase in reducing sugar could be due to the break down of polysaccharides into water soluble sugar.

However, as storage time advances, reducing sugar content declines. Similar changes were also observed by Salunkhe et al. (1975). Other findings also indicated that starch is completely hydrolyzed into soluble sugar such as glucose, fructose and sucrose as ripening progresses (Matto et al., 1975). The breakdown of polysaccharides into water soluble sugar might be a reason for an increase in the sugar content. The findings of Matto et al. (1975) also indicated that starch is completely hydrolyzed into soluble sugar such as glucose, fructose and sucrose as ripening progresses. The equations to show the effect of storage period (x) on reducing sugars (y) for sample A, B, C and Control are given as follows:

\( y = -0.07x^2 + 0.1127x + 2.008 \) (R\(^2\) = 0.8273)

\( y = -0.0479x^2 + 0.3541x + 1.714 \) (R\(^2\) = 0.7192)

\( y = -0.07x^2 + 0.522x + 1.568 \) (R\(^2\) = 0.9915)

\( y = -0.0614x^2 + 0.5126x + 1.71 \) (R\(^2\) = 0.9706)

4. CONCLUSION:

It can be concluded from the present experiment that the edible coating affects positively on the physicochemical parameters of tomatoes. The coated sample shows significant difference in almost all parameters as compared to control sample. Within coating treatments the treatment A containing 4% SPI, 0.2% CMC, 1% OA was found to be most suitable for all parameters except vitamin C content where coating treatment C containing 4% SPI, 0.2% CMC, 1% OA, 0.4% AA was found to be most suitable. As far as storage period is concerned as the storage period increase the quality parameters like pH, TSS, total sugar and reducing sugar increases gradually while parameters like acidity and vitamin content decreases. Thus it is observed that composite edible coating can satisfactorily enhance the shelf life of tomatoes stored at ambient conditions.

5. REFERENCES:

• Lambeth VN, Fields ML, Huecker DG (1964) The sugar-acid ratio of selected tomato varieties. Mo Agric Exp Stn Bull 850: 421–423