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Development of an edible coating enriched with cauliflower stalk extracts and star anise essential oil and to evaluate its effect on shelf-life quality of green bell peppers

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Abstract
Bell peppers *(capsicum annum)* also called as capsicum belongs to the Solanaceous family, they are nutritionally rich especially high in vitamins. However one of the major limitations of bell peppers is shorter shelf life of up to 2-3 days when stored at room temperature. Among the various shelf life extension techniques, the application of edible coating is seen to be one of the potential methods to protect the fruit from spoilage. Therefore the primary aim of this study was to enhance the shelf life of bell peppers using edible coating enriched with antioxidants. Green bell peppers were coated with cauliflower stalk extracts (polyphenols) & star anise essential oil due to its antioxidant and antimicrobial properties. Four levels of variations were used (CSE1, CSE2, CSE3, CSE4) and the bell peppers were coated at room temperature using an immersion technique. The effect of the coating treatment on bell peppers were analyzed based on experimental analysis such as PH, TSS (Total Soluble Solids), weight loss%, microbial plate count, and sensory analysis using a 9-point hedonic scale. From the experimental analysis it was found that the sample CSE2 was high in TSS value (5.7 ° Brix). The sample CSE4 had a higher pH value of 6.6, whereas the control sample had the least pH value of 5.26. On observation it was found that the control sample had significant weight loss% and high spoilage rate, whereas, among the coated samples, CSE4 was found to have lesser weight loss %.The sample CSE4 had less microbial growth when compared to other coated samples. The sensory analysis revealed that the sample CSE1 ranked the highest in terms of color, appearance, texture, and overall acceptability, whereas the control sample has resulted in an extreme spoilage rate with least sensory scores. Therefore from the current study it can be seen that the use of edible coating was an effective way of extending the shelf life of bell peppers, the samples CSE1 and CSE4 was highly preferred in terms of sensory analysis and experimental analysis.

Keywords: bell peppers, edible coating, cauliflower stalks, star anise

Introduction

Bell peppers *(capsicum annum)* also called sweet pepper or capsicum that belongs to the Solanaceous family. It is enriched with vitamins such as A and B, vitamin B complex, and a high content of ascorbic acid. In recent years, the consumption and demand for bell peppers have increased. The most important factors of the bell peppers which contribute to the marketability are color, texture, flavor, appearance, nutritional value, and microbial safety.

The post-harvest losses of fruit occur during handling, transport, and storage. Generally, bell peppers have a shorter shelf life of about 3 to 5 days when it is stored at room temperature. During the storage of this fruit, there are several changes that takes place such as shriveling, wilting, flaccidity, and fungal injury which leads to the spoilage of the fruit (Abad Ullah. *et al*, 2017) [1]. Another limitation of the fruit quality is the change in the green color of the product which is due to the degradation of chlorophyll. This change in the sensory property of the fruit is considered a critical factor among the consumers during purchasing bell peppers (Artés *et al*, 2003) [2]. Normally, fruits are stored at low temperatures to delay spoilage. Freezing has also been one of the traditional methods of preservation of bell peppers. This method has been adopted to preserve the sensory and nutritional properties of the fruit. But this method of storage leads to chilling injury. Another traditional method of minimizing quality losses is by controlling the respiration and transpiration rate, reduction of microbial infection, and modified atmospheric storage of the fruit (Bisen and Pandey, 2008) [3]. However, this method of preserving the fruit quality does not possess a beneficial effect on storage. So, the modern technique of the preservative method has emerged.

Food grade edible coating has been the well-proven method of preservation of fruits and vegetables which improves the shelf life of the product and also maintains its quality for a longer period of time. Edible coatings on fruits act as the greatest barrier against gas or moisture. An edible coating is a thin layer of material that is made to form on a food product by using a suitable method of coating procedure. Application of this edible coating combined with biopolymers such as plant extract (polyphenols), essential oil, glycerol (plasticizer), and starch (polysaccharide) is considered as a beneficial method of preserving the fruit which helps in improving the quality and also facilitate the product safe for consumption. These coating materials develop a modified atmosphere which helps to induce diverse alterations in the food products in certain areas such as microbial growth inhibition, sensory qualities, antioxidant properties, and ethylene production (Ali, M. T. M. Muhammad *et al*, 2011) [4].

Each of these biopolymers has its own individual properties which help in maintaining the product quality. These properties of the coating material help in maintain the external and internal quality of the fruit by prolonging its shelf life. The use of edible coating combined with other

components helps to protect the fruit from spoilage by extending its shelf at room temperature. It helps in preventing the fruit from oxidation and also helps in maintaining the green color of the bell peppers. Edible coatings act as the greatest barrier against gas or moisture. (D. Martínez-Romero *et al*, 2000) [5].

Therefore primary objective of the present study was to extend the shelf life of bell peppers at room temperature by using an edible coating rich in bioactive compounds such as cauliflower stalk extracts and star anise essential oils and to analyze the samples based on experimental analysis such as weight loss, pH, TSS, microbial analysis and sensory evaluation.

Materials and methods

Procurement of Ingredients

The raw materials such as Green bell peppers (*Capsicum annum*), Cassava starch, cauliflower stalks, glycerol and star anise essential oil were purchased from the local markets.

Methodology

Various components such as polysaccharides, lipids and bioactive compounds were used for the preparation of edible coating. The components of edible coating includes:

- Polysaccharide-Cassava starch,
- Lipid/plasticizer- Glycerol
- Bioactive compounds-Cauliflower stalk extract(rich in antioxidants)
- Star anise essential oil(rich in antioxidant)

Preparation of cauliflower stalk extract

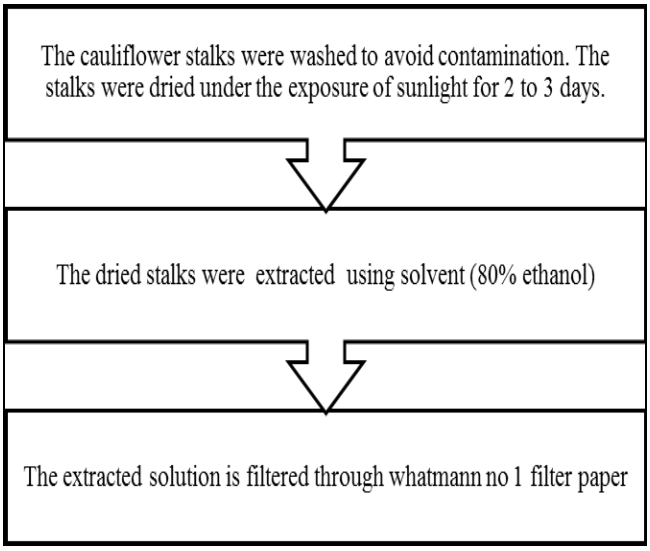

Fig 1: Preparation of cauliflower stalk extract

The bell pepper samples that were treated with varying amount of coating solution were coded for the purpose of convenience.

Table 1: Product code

Cassava starch-cauliflower stalk extract (10ml)	CSE1
Cassava starch-cauliflower stalk extract (15ml)	CSE2
Cassava starch-cauliflower stalk extract (20ml)	CSE3
Cassava starch-cauliflower stalk extract (25ml)	CSE4

Preparation of Coating solution

Table 2: Formulation of coating solution

Variation	Cassava starch	Glycerol (ml)	Distilled water (ml)	Cauliflower stalk extract (ml)	Star anise essential oil (ml)
CS	-	-	-	-	-
CSE1	10	2	100	10	1
CSE2	15	5	150	15	1
CSE3	20	5	150	20	1
CSE4	25	7.5	200	25	1

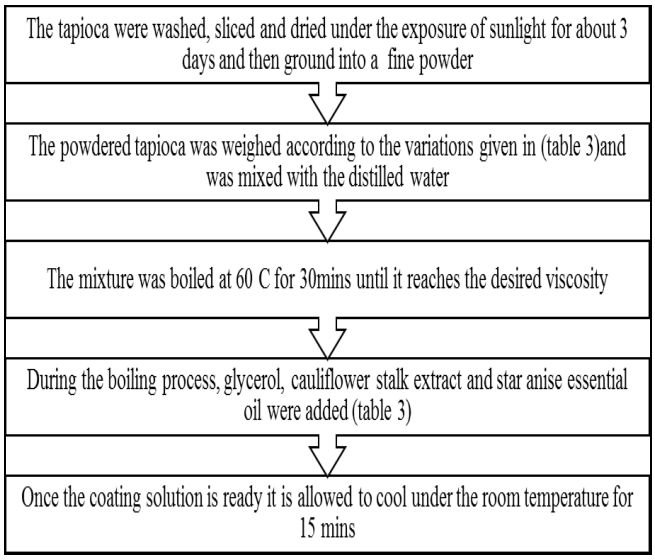

Fig 2: Steps in the Preparation of coating solution

Coating procedure

The initial weight of the bell peppers were taken, after which they are washed with water to clean the surface. Then the bell peppers were coated with coating mixtures by immersion technique. The coated samples were allowed to air dry. After complete drying, the samples were kept at the room temperature for shelf life study. A fresh bell pepper (without coating) was weighed, washed thoroughly and kept it for observation at room temperature to evaluate the difference between both the samples. The non-coated sample was coded as CS.

Experimental analysis

Weight loss %

Initial weight of the samples was taken. After which the weight of the coated samples were measured at the 3rd day and the final day (8th day), using a weighing balance.

The weight loss% was calculated using a formula (Abad Ullah *et al*, 2017) [1]

$$\text{Weight loss \%} = \frac{W1-W2}{W2} \times 100$$

pH

pH of the bell pepper fruit juice was measured by using a digital pH meter.

Total soluble solids

TSS of the bell pepper (juice was taken) was Determined (1) in ∘ Brix by placing a juice drop on the lens of a handheld refractometer.

Microbial plate count

The microbial growth was studied using pour plate technique. The samples were homogenized and dilutions were made. The nutrient agar was used as a growth media. After plating the samples were kept in incubator at 37 ° C for 24 hour observation. The plate count was taken by using digital plate count meter.

Sensory analysis: Sensory analysis was carried out for all sample variations by using a 9-point hedonic scale rating tests. Seven semi-trained panelists participated in the study to carry out the evaluation process. The panelists were provided with an sensory evaluation sheet, each of the bell pepper sample were analyzed based on four sensory attributes- Color, appearance, texture and overall acceptability. The samples were presented in a randomized order to the panel members.

Results and discussion

Weight loss

Water is an important component in bell peppers. The weight loss percent of bell peppers were calculated during the 3rd and the 8th day. A significant weight loss was noted in all the bell pepper samples, however, the weight loss % of coated samples was less in comparison to uncoated sample. The coating treatment was seen to be effective in the sample CSE4 as the weight loss percent (6.95%) was less compared to other variations and control sample. The sample CSE1 showed about 11.44% weight loss during a storage period of eight days which was comparatively less to that of the other variations. The control sample ranked the highest in weight loss percentage (20.48%) during the 8th day of storage at room temperature.

The results of this study can be correlated with a study conducted by Sirchit and John M (1996)[6], were a mineral oil coating was seen to be an effective treatment on bell peppers which has reduced the moisture loss and prolonging the freshness of the bell peppers. Therefore edible coating can be an effective method for increasing the shelf life of bell peppers.

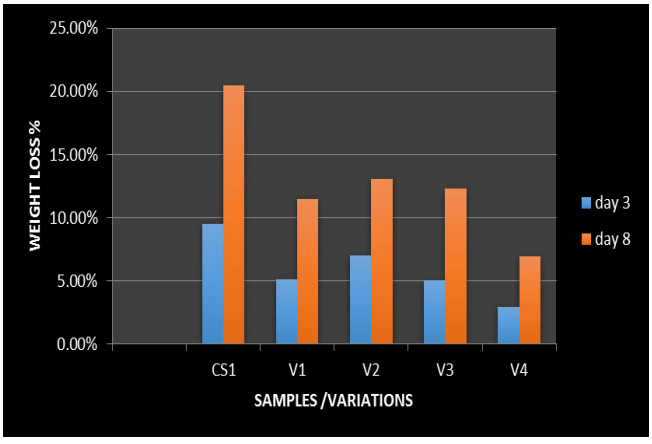

Fig 3: Weight loss % of bell peppers during the 3rd and 8th day

Total soluble solids

The TSS values were taken at the end of 8th day. The sample CSE2 had the highest total soluble solids compared to other samples during the storage life of the bell peppers. The TSS value ranged between 5.3 to 5.7 for the coated samples, and comparatively lesser TSS was found in the control sample that is 4.83 ° Brix.

Table 3: Total soluble solids of bell peppers (8th day)

Sample	TSS
CS	4.83±0.3
CSE1	5.3±0.3
CSE2	5.7±0.45
CSE3	5.5±0.3
CSE4	5.6±0.2

*values in Mean±SD (Triplicates)

pH

The pH values varied significantly among different variations. The sample which had higher amount of coating treatments (CSE4) ranked the highest in pH values (6.66±0.20) in comparison to other treatments. The control sample had the lowest pH value (5.26±0.05).

Table 4: pH values (8th day)

Sample	pH
CS	5.26±0.05
CSE1	5.56±0.12
CSE2	5.84±0.1
CSE3	5.8±0.13
CSE4	6.66±0.20

*values in Mean±SD (Triplicates)

Total plate count

Table 5: Total plate count (Cfu/ml)

Sample	Cfu/ml
CS	140
CSE1	50
CSE2	47
CSE3	48
CSE4	46

The microbial growth of various samples was studied using pour plate technique. The results of microbial analysis revealed that the sample CSE4 had the lowest colony forming units, followed by the samples CSE3, CSE2 and CSE1. Therefore it can be seen that the antioxidant and antimicrobial properties of the coating material have significantly reduced the microbial growth in the samples and thereby preventing the spoilage of the bell peppers during 8 days of storage life.

Sensory analysis

Day1: Evaluation of sensory parameters of bell pepper samples coated with varying levels of incorporations.

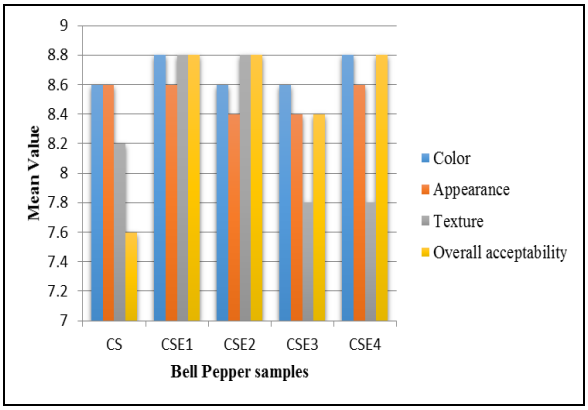

Fig 4: Sensory data of samples on day 1

The bell pepper samples were coated with cauliflower stalk extracts at various levels of incorporations and the samples were analyzed based on various sensory attributes like color, texture, appearance and overall acceptability. On day 1 it was found that all the coated samples had higher ranking in terms of all the sensory attributes when compared to the control samples. The sample CSE1, CSE2 and CSE4 had the wide acceptability compared to CSE3 and control sample.

Day 5: Evaluation of sensory parameters of bell pepper samples coated with varying levels of incorporations.
The bell pepper samples were analyzed based on various sensory parameters on day 5. From the results of the sensory data it can be seen that the sample CSE1 had the highest overall acceptability in comparison to other variations and control samples. The controls samples showed significant deterioration and it was the least ranked when compared to other samples. The sample CSE1 had higher ranking in terms of color (7.6±0.54), Appearance (7.6±0.54) and texture (6.8±0.44) compared to other variations. Therefore it can be seen that sample CSE1 was widely preferred by the semi trained panelist.

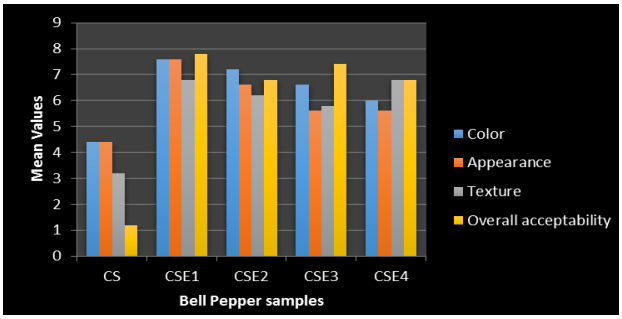

Fig 5: Sensory data of samples on day 5

Day 8: Evaluation of sensory parameters of bell pepper samples coated with varying levels of incorporations.
After 8 days of storage at room temperature it can be seen that the control sample had an extreme spoilage rate with the mean values of Color (1.6±0.54), Appearance (1.4±0.54), Texture (1.2±0.44) and Overall acceptability (2.6±0.54). The sample CSE1 had the highest ranking in terms of Color (7.2±0.44) and overall acceptability (7.8±0.54) in comparison to other variations. The sample CSE4 had the highest textural acceptability (7.6±0.44) and it was also widely accepted for its appearance (6.8±0.44). Therefore it can be seen that all the coated samples had an acceptable shelf-life and the treatments had a positive effect on the bell pepper samples when compared to control sample.

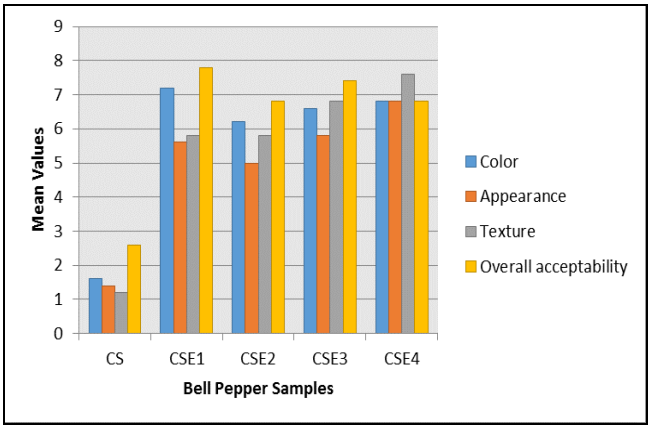

Fig 6: Sensory data of samples on day 8

Fig 7: Day1

Fig 8: Day 5

Fig 9: Day 8 *(sample- CS, V1- CSE1, V2- CSE2, V3-CSE3, V4-CSE4)

Conclusion

Bell peppers *(capsicum annum)* also called sweet pepper or capsicum that belongs to the *Solanaceous* family. One of the major limitation of bell peppers is shorter shelf-life of the produce. Therefore the main aim of this study was to formulate an edible coating enriched with antioxidant rich cauliflower stalk extracts and star anise essential oil and to analyze its effect on the shelf-life quality of bell peppers. Experimental analysis (Weight Loss %, pH, TSS and Microbial analyses) and Sensory analysis was conducted for the samples. It was seen that the control sample had the highest weight loss percent when compared to the coated samples and the sample CSE4 was seen to be the most effective and had lesser weight loss percent. On day 8 it was found that the sample CSE2 had a higher TSS value and sample CSE4 had higher pH when compared to control sample and other variations. The sample CSE4 also had less microbial plate count when compared to other samples. In terms of sensory analysis it was found the sample CSE1 had the highest overall acceptability when compared to the control sample. Therefore from this study it is concluded that the edible coating treatment have significantly increased the shelf-life of bell peppers, the samples CSE1 and CSE4 was highly preferred in terms of sensory analysis and experimental analysis.

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