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Research Article

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Development of Mint (*Mentha viridis L.*) Herbal Edible Coating for Shelf Life Enhancement of Cucumber (*Cucumis sativus*)

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Abstract: In the present research the corn starch and mint (*Mentha viridis L.*) extract herbal edible coating was applied on fresh cucumbers for enhancement of their shelf life and quality stored at room temperature and low temperature i.e. 25°C and 10°C. The corn starch has good moisture and gases barrier properties while mint extract acted as an antimicrobial agent in this herbal edible coating therefore herbal edible coated cucumbers have long shelf life as compared to uncoated cucumbers. The weight loss of coated cucumbers was significantly ($p<0.05$) less as compared to uncoated cucumbers. The other quality parameters such as appearance, firmness, pH and titratable acidity were also analysed and it was found that herbal edible coated cucumbers were better as compared to uncoated cucumbers. Sensory evaluation of herbal edible coated cucumbers such as taste, color, appearance, texture, flavor and overall acceptability was better at low temperature (10°C) and room temperature (25°C) stored at 12 days as compared to uncoated same days.

Keywords: Herbal Edible Coating, Corn Starch, Mint Extract, Cucumber and Shelf life.

INTRODUCTION

The Cucumber (*Cucumis sativus*) is most common growing vegetable belongs to the family "Cucurbitaceae", it is one of the most popular crop grown all over the world. Cucumber mainly grown in summer season; the production of cucumber crops in the world is over 40,000 tones, where the first producer country of cucumber is China followed by Turkey, Iran, Russia and Ukraine.

Cucumber is a most important crop which can be consumed as raw vegetable as a salad or in some countries consumed in cooked form. The cucumber is a perishable vegetable as appearance and sensory quality reduces rapidly; quality of this fruit is highly decreased after harvesting due to shriveling, water loss and changes in their color, if not stored properly. The shelf life of cucumber in the market maximally limited to 2-3 days[1]. The production of cucumber is also affected by the attack of certain parasites (downy mildew, powdery mildew and fungal disease) and insects[2]. There are significant price fluctuations which can be overcome by adopting various storage methods.

Cucumbers are not stored at temperature below 7-10°C because the cucumber is highly chilling sensitive vegetable and at low temperature chilling injury develops in cucumbers and it increases the decay tendency[3-5]. Decay, shriveling and yellowing are likely to increase after storage of more than 6 days or a week.

To maintain the quality and enhancing the shelf life of cucumber during storage period, many techniques and treatments are already being used for extending post harvest life of cucumber such as modified atmospheric packaging (MAP), controlled atmospheric packaging (CA), fungicides and chemical preservatives; However, all these preservation methods are having some drawbacks such as most methods are non-biodegradable, less economical, MAP in cucumber sometime alleviates chilling injury and most important drawback is fungicides and chemical preservatives are harmful for human health[6].

Nowadays edible coating is one of the most important alternative and innovative technique which are highly used in Postharvest Industry for enhancing postharvest life of fresh fruits and vegetables. Edible coating is a thin layer edible material which is applied on fresh fruits and vegetables; it can be consumed with food together. Edible coatings are enhancing the shelf life of fruits and vegetables. Edible coating is a new and innovative technique which is developed for maintenance the quality of fruits and vegetables by preventing the changes in color, texture, size, shape, appearance, aroma and flavor [7, 8].

Carbohydrates are mostly used for edible coating preparation. Starch amylose for example corn starch is good source for preparation of edible coating. Corn starch based edible coating has physical characteristics similar to the plastic coatings and films; it is biologically absorbent and semi-permeable to gases, odorless, tasteless, colorless and non-toxic. Thus, the corn starch is fit for human consumption and can be perfect alternative to post-harvest packaging and preservation of different fruits and vegetables such as Cucumber due to their minimum cost, excellent mechanical properties and their biodegradability[9, 10].

Basically the edible coatings are prepared from edible material like carbohydrates, protein, lipid and their combination but at the present time herbal extracts such as aloe vera extract, mint extract, tulsi extract, marigold extract, neem extract and others or their combinations are also used in preparation of edible coatings; this can act as antimicrobial, antioxidant and preservative as well as and known as herbal edible coating. The addition of these extracts making more beneficial herbal edible coating replacing the edible coating [11]. The Herbal edible coatings are eco-friendly alternative to maximize the postharvest life of fresh produces and minimally processed fruits and vegetables [11-14].

MATERIAL AND METHODS

Preparation of Cucumbers for Coating: Cucumbers (*Cucumis sativus*) were procured from the local farmer's field, Jaipur, Rajasthan. The cucumbers selected were fresh, mature uniform size and shape, clean from any type of cuts and patches. The selected cucumbers were divided into four groups on the basis of temperature. In which T_1 was coated cucumbers and T_2 was uncoated cucumbers for low temperature (10°C). While the T_3 used as coated cucumbers and T_4 was used as uncoated cucumbers at room temperature (25°C). Each group was containing 10 cucumbers. The Cucumbers were washed properly from clean with water for 3-5 min and air dried at room temperature (25°C) before applying the herbal edible coating.

Preparation of Herbal Edible Coating

Preparation of Mint extract: Fresh Mint (*M. viridis L.*) leaves were procured from the University farm. The fresh mint leaves were separated from stem and washed with water for 5-7 minutes than shade dried for 4-7 days at room temperature (25-30°C). The dried mint leaves were placed into hot air oven for 20 min at 65-70°C and preparation of powder by using mixer grinder. The mint leaves extract was prepared by using Soxhlet apparatus at 78°C, distilled water used as solvent. The mint leaves extract was evaporated and air dried at room temperature.

Herbal Edible Coating Preparation: The Herbal edible coating was prepared by using mint extract and corn starch. For preparing the coating, the corn starch was used as a base material of edible coating. The herbal edible coating solution was prepared by addition of 2.5 gm corn starch and 1.5 gm mint leaves extract dissolved in 100 ml distilled water with agitation for 10-15 min at 90°C respectively. Maintain the pH by addition of 50% (w/v) citric acid solution. The glycerol was added as a plasticizer and concentration was used 2 ml/lit.

Treatments

- **T_1:** Herbal edible coated cucumber at low temperature (10°C).
- **T_2:** Uncoated cucumber (control) at low temperature (10°C).
- **T_3:** Herbal edible coated cucumber at room temperature (± 25°C).
- **T_4:** Uncoated cucumber at room temperature (± 25°C).

Application of Herbal Edible coating: The herbal edible coating applied on cucumber by brushing method and then the residual coating solution was allowed to drip off for a minute. When the cucumbers get dried completely after coating, they were stored at room temperature (25°C) and low temperature (10°C) for physiochemical analysis.

Physiochemical Analysis

Weight Loss: The weight loss was analyzed by using the method of **AOAC**[15] at every 3rd day. The weight loss was determined by the formula-

$$\textbf{Weight loss \%} = \frac{\mathbf{Wi \times Wf}}{\mathbf{Wi}} \times \mathbf{100}$$

Where, Wi is Initial weight of sample and Wf is Final weight of sample.

Firmness: Firmness was determined by using of instrument Hand Penetrometer (WAGNER) with its probes (FT-5/16). The cucumber was cut into two halves held and each half was determined in the middle zone. Firmness was measured in "kgf" [15].

Total Soluble Solids (TSS): Total soluble solid (TSS) was determined by the method explained in **AOAC**[15]. The TSS was analyzed by using of Hand Refractometer (ERMA, Japan) in °Brix or %. The cucumber was picked for each group, both coated and uncoated then these were grounded by mortar-pestle and juice extracted by squeezing the juice with muslin cloth. Freshly prepared cucumber juice was used for analysis.

pH: Cucumber juice was freshly prepared. The cucumber juice was homogenised and then filtered for pH analysis. pH was determined by using Digital pH meter [16].

Titratable Acidity (TA): The titratable acidity was analysed as the volume (ml) of NaOH (0.1N/L) required for titrating the 5-10 ml of the cucumber juice sample for titration. The result was calculated as percentage of citric acid [15]. In cucumber juice the citric acid was found predominant organic acid, the milli-equivalent weight of citric acid is 0.064.

$$\text{TA (\%)} = \frac{(\text{mls of NaOH used}) \times (\text{miliequivalent factor})}{\text{mls of sample}} \times 100$$

Sensory Evaluation: The sensory evaluation was performed by using 9 point Hedonic scale, by semi-trained panel members having 10 or 12 panel members. The panel members were provides a 9 point hedonic scale questionnaire to test appearance, color, taste, texture, flavor, after taste and overall acceptability of coated cucumber and control. They were scored on a scale of 1-9 (1=dislike extremely, 2=dislike very much, 3=dislike moderately, 4=dislike slightly, 5= neither like nor dislike, 6= like slightly, 7= like moderately, 8 = like very much and 9= like extremely).

Statistical Analysis: The data was analyzed by using the one way analysis of variance (ANOVA). The significant level used was 0.05. For all statistical analysis Microsoft excel 2007 and GraphPad Prism was used.

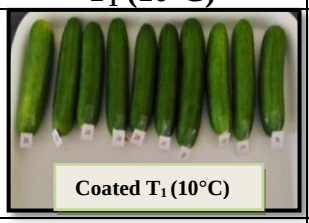
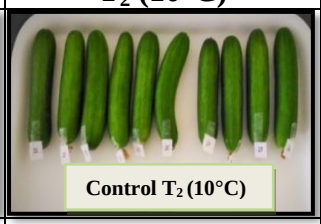
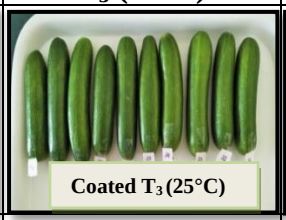
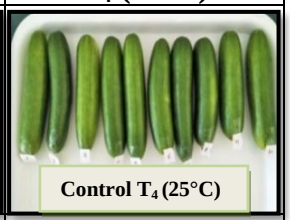
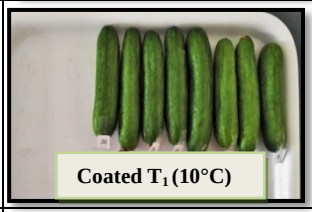
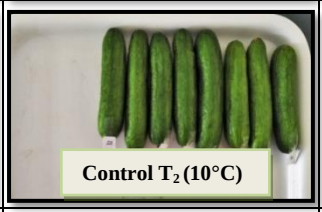
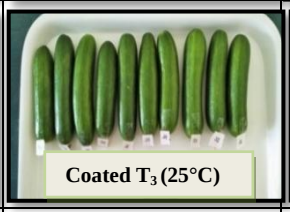
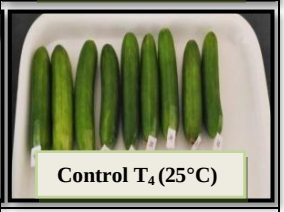
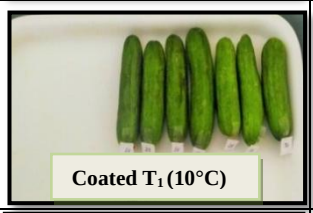
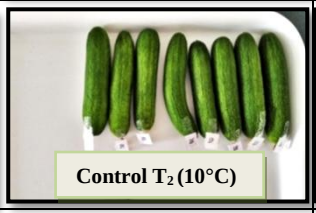
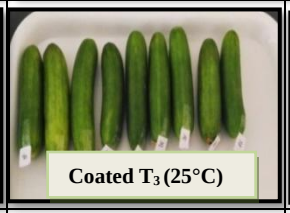
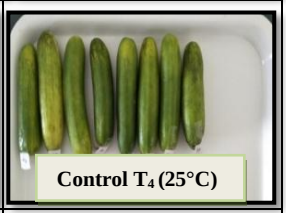
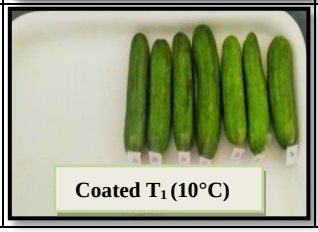
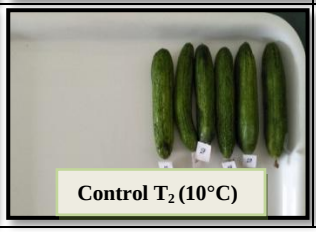
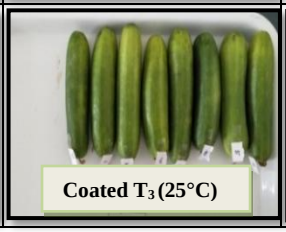
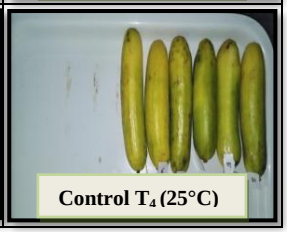
RESULT AND DISCUSSION

Physical appearance: The physical appearance changes in cucumber as influenced by storage time and treatment with corn starch and mint extract is shown in Table 1. Generally, corn starch and mint extract based herbal edible coating resulted in better appearance as compared to uncoated cucumber. There was a dull or yellowish appearance in uncoated cucumber on 9th day at room temperature (25°C) but in another study[17] was observed that the peel colour of uncoated cucumber remained dark green in 6 days of storage at room temperature while the coated cucumber was found yellowish on 12th day.

On the other hand the uncoated cucumber stored at low temperature (10°C) could retain acceptable appearance until 12th day but surface of uncoated cucumber was dull and shrink as compared to herbal edible coated cucumber. Hence the herbal edible coating influenced and maintained the appearance and color of cucumbers at low temperature (10°C) and at room temperature (25°C) also.

In freshly harvested green fruits and vegetables, yellow carotenoids coexist with green chlorophylls. During ripening process of fresh produce, chlorophyll constantly decreases, exposing the lighter yellow pigments, also if stored for a long time, most green vegetables will undergo eroding of chlorophyll [18], which shortens its shelf life and affects quality [19].

Table 1: Physical appearance of coated and uncoated cucumbers at room and low temperature (25°C & 10°C) during storage period.

Days	T_1 (10°C)	T_2 (10°C)	T_3 (25°C)	T_4 (25°C)
3rd				
6th				
9th				
12th				

Weight loss: There was a significant difference ($p<0.05$) in the weight loss of herbal edible coated and uncoated cucumbers during storage period. The weight loss in cucumbers increased in all the coated and uncoated cucumbers as the progress of storage time.

On 3rd day of storage period the minimum weight loss was found in coated samples i.e. T_1 and T_3 (0.99% and 1.08%) while maximum weight loss was observed in uncoated cucumbers i.e. T_2 and T_4 (1.23% and 1.33%) at room temperature and low temperature (25°C and 10°C). On 12th day after coating application, the lower weight loss was reported in coated cucumbers; T_1 (11.82%) and followed by T_3 (12.94%), where as it was higher in uncoated cucumbers i.e. T_2 (12.99%) and followed by T_4 (15.57%) at the both temperatures (10°C & 25°C). The weight loss of coated and uncoated were statistically significant ($p<0.05$) during storage time. The weight loss percentage increased in coated and uncoated (control) cucumbers as the storage time progressed.

The weight loss in fresh fruits and vegetables is mainly caused by respiration and transpiration process[20]. The wilting and shriveling of fresh produce due to water loss decreases the commodity price in the market thus act as a limiting factor of marketability. Edible coatings decreases the rate of respiration and transpiration of fresh produce by formation of a semi-permeable membrane and this membrane act as a protective barrier against gases O_2, CO_2 and Ethylene [21]. The minimum weight loss of coated cucumber reduced by the corn starch and mint based herbal edible coating at low (10°C) and room temperature (25°C), it provides good barrier against diffusion of moisture, O_2, CO_2 and solute movements, thereby reducing water loss and respiration rate.

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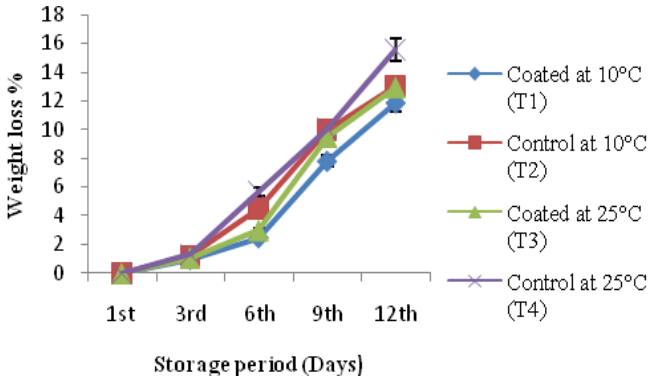

Fig 1: Effect of herbal edible coating on weight loss of cucumbers during storage at 10°C & 25°C.

Cucumber coated with corn starch and mint extract presented best results for weight loss when as compared to other coatings. According to Ghosh *et al*., [22, 23] corn starch was effective for decrease the weight loss in lemon, sapota and other fruits and vegetables and also enhances the shelf life. At the end of storage period, the weight loss was found to be highest for uncoated cucumbers showing high weight loss of 12%. Oluwaseum *et al*., [24] has been reported similar results in CMC (carboxy-methyl cellulose) and corn starch coatings applied on cucumber at room temperature. In another research of Adetunji *et al*.**,** [25] corn starch enhanced the shelf life of orange.

pH: The herbal edible coated and uncoated cucumber juice was analyzed for their pH value regularly during storage period. The results have revealed that the cucumbers stored at room temperature demonstrated gradual decrease in pH with the increase in storage time for herbal edible coated and control cucumbers. There were no significant differences found between coated and uncoated cucumbers, although the corn starch and mint extract based herbal edible coating indicated higher pH at the end of 12th day storage at room and low-temperature.

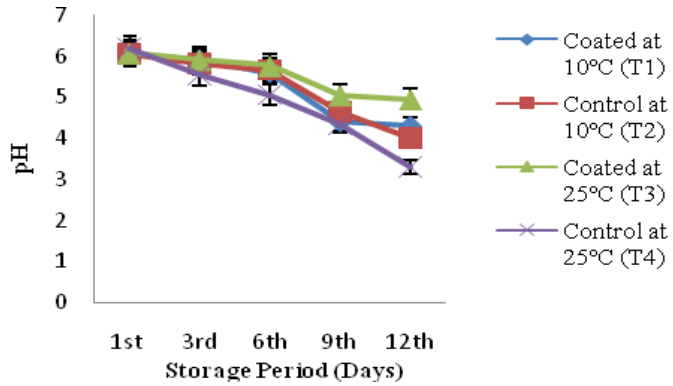

Fig 2: Effect of herbal edible coating on pH of cucumber during storage at 10°C and 25°C

Adetunji *et al*. [27] and Oluwaseun *et al*. [24] were found similar results in chitosan-*Aloe vera* coated cucumbers and corn starch & carboxy-methyl cellulose coated cucumbers, respectively. Saha *et al*., [27] also reported the similar result as found in our research that the guar based edible coated cucumber also decrease the pH as compared to uncoated cucumber.

The pH was decreased due to the edible coating which forming a semi-permeable membrane on the surface of fruits and vegetables, it's modified the internal atmosphere i.e. the endogenous CO_2 and O_2 concentration of the fruits and vegetables, thus retard the ripening process. The reduction of pH can be attributed to the utilization of accumulation of citric acid in the endocarp of cucumber. However,

uncoated cucumbers had greater pH decrease during storage as greater utilization of organic acids stored in the vacuoles as respiratory substrate[28] as compared to coated because the herbal edible coating acted as a protective layer around the fresh produce which may result in less accumulation of acids inside the vacuoles. Hence, general decrease has been observed in coated cucumbers as compared to uncoated cucumbers (control) where herbal edible coated in combination of corn starch and mint extract gave best results in retention of pH as compared to other coatings.

Firmness: The firmness of the uncoated (control) cucumber was significantly ($p<0.05$) decreased with storage period and reached 4.2 kgf (T_2) and 3.6 kgf (T_4) on 12th day at 10°C and 25°C, respectively. Cucumbers coated with herbal edible coating had been found significantly having higher value of firmness [4.7 kgf (T_1) and 4.3 kgf (T_3)] during storage period as compared to uncoated cucumbers. Thus firmness decreased gradually during storage period at the same temperature. The results indicated that the corn starch and mint based herbal edible coating significantly retained the firmness of cucumber and acted as a barrier against water loss and nutrient. Uncoated cucumbers clearly indicated the lowest firmness at the end of 12th day of storage period on both temperature i.e. 10°C and 25°C. The corn starch and mint based herbal edible coating maintained the maximum firmness of coated cucumbers until 12th day of storage at the low and room temperature (10°C and 25°C).

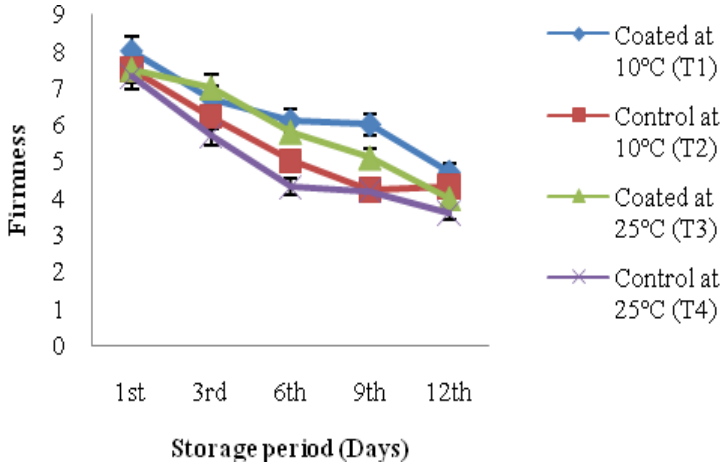

Fig 3: Effect of herbal edible coating on firmness of cucumbers during storage at 10°C & 25°C.

The firmness or softening of fruits and vegetables caused by composition of cell wall, deterioration of cell structure and intracellular material[29] and decrease in firmness is a biochemical process involving the pectin and starch hydrolysis by enzyme e.g. wall hydrolases.

As the process of fruits and vegetables ripening progresses, the chain length of pectin is depolymerized or shortened. The substances found with an increment in polygalacturonase and pectinesterase activities[30]. The high level of CO_2 and low level of O_2 limit affected the activities of these enzymes and allow retention of the firmness during storage [31]. Reduced in respiration rates of herbal edible coated cucumbers could be responsible for delaying softening which resulted in retention of firmness during storage period.

Total Soluble Solid (TSS): The TSS for herbal edible coated cucumbers were 4.6% (T_1) and 4.5% (T_3) while the value for uncoated (Control cucumbers) was 3.2% (T_2) and 2.4% (T_4) at low and room temperature (10°C and 25°C) respectively. These results were similar with those of Smith and Stow[32] in which they concluded that coatings and films significantly affected TSS. The Total soluble solids (TSS) of coated and uncoated cucumbers stored under the ambient temperature decreased at the end of the storage period. The reduction of total soluble solids at the time of storage period is as natural as

sugar which is the basic constituent of the TSS of a product, used in respiration process for metabolic activities of the fresh fruits and vegetables [33].

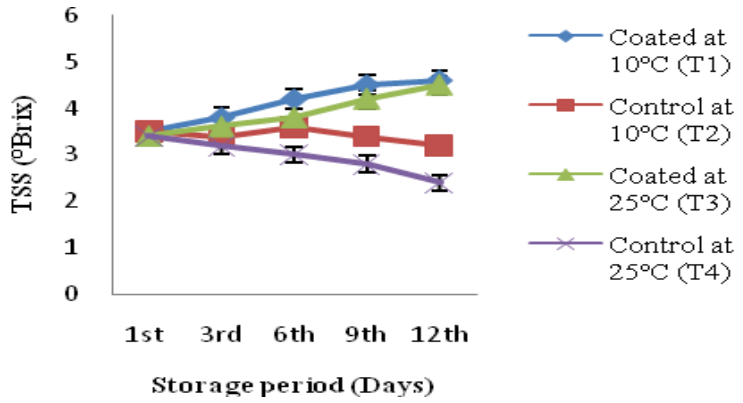

Fig 4: Effect of herbal edible coating on total soluble solids (TSS) of cucumbers during storage at 10°C and 25°C.

With an increase in storage period, the corn starch converts into sugar in the tissues which denotes an increase the TSS [18, 34]. Herbal 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 cucumber as compared to uncoated (control) which implies changes in TSS in coated cucumbers were slower than uncoated cucumber.

Titratable acidity: The values of titratable acidity of herbal edible coated and uncoated cucumbers were reduced with storage period. During the storage, the lowest value of titratable acidity was T_2 (0.08%) and T_4 (0.12%) observed in the uncoated cucumbers, as the highest titratable acidity reported in coated cucumbers i.e. T_1 (0.089%) and T_3 (0.148%). The titratable acidity was found highest in coated cucumbers on 12th day of coating treatments stored at low temperature (10°C) and room temperature (25°C) while the lowest titratable acidity value was reported in uncoated cucumbers at the same storage day and temperature. Omoba and Onyekwere[35] reported same results of titratable acidity (%) in chitosan and lemongrass extract coated cucumbers.

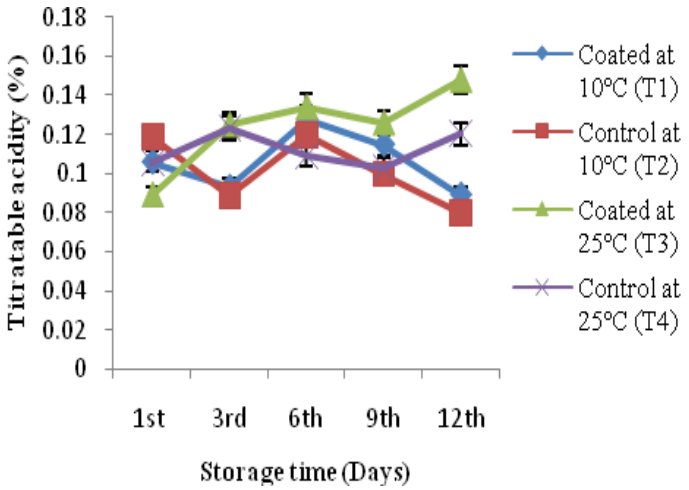

Fig 5: Effect of herbal edible coating on titratable acidity of cucumbers during storage at 10°C and 25°C.

The maximum percentage of titratable acidity of cucumbers was found in corn starch and mint extract herbal edible coated cucumbers delayed ripening by providing a semi-permeable layer around

cucumbers and hence which decreased the metabolic rate of the coated fruits and vegetable. The decrement in titratable acidity is an important process during ripening, as it renders the fruits and vegetables less sour and acidic.

Since the organic acids, such as citric acid, malic acid, are basic substrate for respiration, a decrement in acidity is expected in respiring fruits and vegetables. Hong *et al.*[37] has been reported that the faster process of decrement in acidity faster the senescence. Corn starch and mint extract based herbal edible coating applied on cucumbers might hereupon decreases the rate of respiration and stopped the utilization of organic acids which will result in lower loss of acidity in cucumbers.

Sensory Evaluation: The sensory evaluation of cucumbers coated and uncoated with corn starch and mint extract based herbal edible coating at the end of storage were summarized in table 2. In case of the sensory evaluation of the shelf life of the coated cucumbers, it can be seen that the corn starch and mint based herbal edible coating significantly ($P<0.05$) improved the shelf life of the cucumbers, maintaining the visual quality (appearance and color with scores ≥8.8) during the storage time as compared to uncoated cucumbers. No significant difference ($p\geq0.05$) was found in texture and no significant difference was observed in appearance, taste, texture, color, and flavor and after taste assessed for coated and uncoated cucumbers fruits at the end of day 12 at room temperature (25°C).

Table (2): Sensory evaluation of cucumbers after storage at 10°C & 25°C.

Quality Parameters	Treatments	Storage Time			
		3rd	6th	9th	12th
Appearance	T_1	8.8±0.32a	8.2±0.56ab	8.5±0.45b	7.2±0.57a
	T_2	8.4±0.43a	7.5±0.76a	6.8±074ab	5.4±0.89b
	T_3	8.6±0.38ab	7.7±0.75a	7.6±0.76a	-
	T_4	8.1±0.54b	6.4±1.16	5.1±0.92	-
Taste	T_1	8.9±0.21a	8.3±0.47	8.4±041	7.1±0.79b
	T_2	8.3±0.36ab	7.2±0.93	6.5±0.80	6.7±0.93a
	T_3	8.6±0.44a	8.2±0.71	7.5±0.54	-
	T_4	7.9±0.64a	6.2±0.88	5.7±0.64	-
Texture	T_1	8.8±0.31a	8.1±0.62a	8.2±0.64a	7.3±0.72a
	T_2	8.5±0.45a	8.2±0.72a	6.9±0.68a	6.7±0.88a
	T_3	8.4±0.48a	7.7±0.74a	7.2±0.73a	-
	T_4	7.3±0.65a	5.8±1.35a	4.6±087a	-
Color	T_1	8.9±0.29a	8.7±0.47b	8.5±0.62a	7.9±0.79a
	T_2	8.5±0.41b	7.5±0.75ab	7.4±0.76ab	7.3±0.87a
	T_3	8.2±0.66b	7.7±0.10a	7.7±0.73b	-
	T_4	7.6±0.62a	5.2±1.31b	4.4±1.34ab	-
Flavour	T_1	8.7±0.34a	8.1±0.49b	8.1±0.54ab	6.3±065a
	T_2	8.4±0.42b	7.3±0.88a	6.2±1.07a	3.9±1.54a
	T_3	8.6±0.43ab	8.4±0.46b	7.0±0.58ab	-
	T_4	7.9±0.53a	6.2±1.16a	5.5±0.80ab	-
After taste	T_1	8.6±0.40a	8.5±0.48b	8.1±0.59a	6.3±0.91a
	T_2	8.2±0.30b	7.0±0.65a	5.8±1.29ab	3.2±1.63b
	T_3	8.4±0.51a	7.7±0.75ab	7.1±0.53b	-
	T_4	7.5±0.75b	6.0±0.60b	6.0±0.61a	-
Overall acceptability	T_1	8.8±0.14a	8.3±0.23b	8.3±0.25b	7.02±0.24a
	T_2	8.4±0.15b	7.5±0.37a	6.2±0.61ab	5.5±0.66b
	T_3	8.5±0.21b	8.0±0.28b	7.4±0.38a	-
	T_4	7.6±0.31ab	6.0±0.32a	5.3±0.41b	-

Values with the same alphabet along the same row are not significantly different ($p\leq0.05$); uncoated (T_2 & T_4), coated (T_1 & T_3) cucumber; coated with herbal edible coating.

The untreated fruits were as acceptable as those treated with chitosan and lemon grass extracts to the panelists. This agrees with the report of Yahia *et al*.[38] and Omoba and Onyekwere[35] who reported that cucumber can be stored for two weeks. But it was in contrast with the result obtained by Al-Juhaimi *et al.*[39] who reported a significant difference ($p \leq 0.05$) between 20% gum Arabic coated and uncoated cucumbers fruit. In cucumber, the main signs of aging and deterioration in quality are yellowing and shriveling as a result of water loss[40] , but these were not observed in the corn starch and mint extract based herbal edible coated fruits as well as the control uncoated fruits on day 12 of storage. No Significant difference ($p \geq 0.05$) was observed in the overall acceptability of both treated and untreated cucumber fruits.

CONCLUSION

This study concluded that the corn starch and mint extract herbal edible coating extended the shelf life and quality of cucumbers at room temperature (25°C) and low temperature (10°C). Herbal edible coated cucumbers were better for all quality parameters as compared to uncoated cucumbers at 12th day of storage. The herbal edible coating was most effective in reducing weight loss, firmness, pH, TSS and titratable acidity and maintains the visual appearance. This coating had no significant effect on pH and similarly, no significant difference ($p<0.05$) was reported between the sensory attributes considered in coated and uncoated cucumbers. Therefore conclusion of this study is that the herbal edible coating was an effective and healthy source used for enhancement of shelf life of fresh cucumbers.

REFERENCE

1. Y. Funamoto, N. Yamauchi, T. Shigenaga and M. higyo , Effects of heat treatment on chlorophyll degrading enzymes in stored broccoli (*Brassica oleraceae* L.), *Postharvest Biol. Technol,2002,* 24:163-170.

2. T. Anand, A. Chandrasekaran, S. P. Kuttalam, G. Senthilraja, T. Raguchander and R. Samiyappan, Effectiveness of Azoxystrobin in the control of *Erysiphe cichoracearum* and *Pseudoperonospora cubensis* on cucumber, *J Plant Prot Res*, 2008, 48(2): 147-159.

3. A. L. Snowdon, *A Colour Atlas of Post-harvest Diseases and Disorders of Fruits and Vegetables*, Wolfe Aylesbury, 1991, UK. 2.

4. J. R. DeEll, C. Vigneault and S. Lemerre, Water temperature for hydro-cooling field cucumbers in relation to chilling injury during storage, 2000, 8: 27-32.

5. M. U. Kasim and R. Kasim, Vapour 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.

6. C. Y. Wang and L. Qi, Modified atmosphere packaging alleviates chilling injury in cucumbers, *Postharvest Biol Techno, 1997,* 10: 195-200.

7. S. Guilbert , Technology and application of edible protective films, In. Food Packaging and Preservation, (Mathlouthi, M. Ed.), *Elsevier Appl. Sci.*, 1986, 371–94.

8. R. N. Tharanathan , Biodegradable films and composite coatings: past, present and future, *Trends Food Sci. Technol.*, 2003, 14: 71-78.

9. A. M. Mark, W. B. Roth, C. L. Mehtretter and C. E. Rist, Oxygen permeability of amylo maize starch films, Food tech., 1966, 20: 75-80.

10. K. Dey, A. Ghosh, N. Bhowmick and A. Ghosh, Physico-chemical properties of sapota (*Manilkara achras* (Mill) Fosb.) fruits coated with corn starch, *J. Crop Weed*, 2014, 1: 43-49.

11. P. K. Raghav, N. Agarwal and M. Saini, Herbal Edible Coatings of Fruits & Vegetables: A Newer Concept. *IJAR*, 2016, 4(6): 1452-1458.

12. E. A. Baldwin, Edible coatings for fresh fruits and vegetables: past, present, and future, In Edible Coatings and Films to Improve Food Quality (J. M. Krochta, E. A. Baldwin and M. O. Nisperos-Carriedo, Eds.), Technomic Publishing Co. Inc., Lancaster, PA, USA1994,. 25-64.

13. M. B. Perez-Gago, M. Serra, M. Alonso, M. Mateos and M. A. Río, Effect of whey protein and hydroxypropyl methylcellulose-based edible composite coatings on color change of fresh-cut apples, *Postha. Bio. Tech., 2005, 36*: 77-85.

14. M. Vargas, C. Pastor, A. Chiralt, D. J. Mc Clements and C. G. Martinez, Recent advances in edible coatings for fresh and minimally processed fruits, *Crit Rev Food Sci Nutr, 2008, 48*: 496-511.

15. A.O.A.C. Official *Methods of Analysis of Association of Official Analytical chemists*, 7Ed, published by Association of Official Analytical Chemists. U.S.A, 2000.

16. S. Ranganna, *Hand Book of Analysis and Quality Control for Fruit and Vegetable Products*, 2nd Edition, 2003, 1226.

17. S. A. Phal Sargent and D. N. Maynard, *Cucurbits in crop post-harvest: science and technology perishables*, Rees D., Farrell G., Orchard J. (Eds); Blackwell Publishing, West Sussex; 2012,pp. 286-290.

18. M. Moalemiyan and H. S. Ramaswamy, Quality retention and shelf-life extension in Mediterranean cucumbers coated with a pectin based Film, *J. Food Res*, 2012, 1(3): 159-168.

19. A. Fukasawa, Y. Suzuki, H. Terai and N. Yamauchi, Effects of postharvest ethanol vapour treatment on activities and gene expression of chlorophyll catabolic enzymes in broccoli florets, *Postharvest Biol. Technol.*, 2010, 55: 97-102.

20. X. Zhu, Q. M. Wang, J. K. Cao, W. B. Jiang , Effects of chitosan coating on postharvest quality of mango *(Mangifera indica* L. CV. Tainong) vegetables, *J Food Process Preserv*, 2008,32(5): 770-784.

21. H. Dong, L. Cheng, J. Tan, K. Zheng and Y. Jiang, Effect of chitosan coating on quality and shelf-life of peeled litchi vegetable, *J Food Eng*,2004, 64(3): 355-358.

22. A. Ghosh, K. Dey & N. Bhowmick, Effect of corn starch coating on storage life and quality of Assam lemon (Citrus limon Burn), *Journal Crop and Weed*. 2015, 11(1): 101-107.

23. A. Ghosh, K. Dey, N. Bhowmick, P. S. Medda and P. Dutta, Effect of guar gum as edible coatings, *The Ecoscan*, 2014, *6*: 202-207.

24. A. C. Oluwaseun, A. A. Kayode, F. O. Bolajoko, A. J. Bunmi and A. R. Olagbaju, 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.

25. C. O. Adetunji, O. B. Fawole, K. A. Arowora, S. I. Nwaubani, J. K. Oloke, A. O. Adepoju, J. B. Adetunji and A. O. Ajani, Performance of edible coatings from Carboxy-Methyl Cellulose (CMC) and corn starch (CS) incorporated with *Moringa oleifera* extract on *Citrus sinensis*, *AgroSsearch*, 2013, 13(1): 77 – 85.

26. A. Saha, S. Tyagi, R. K. Gupta and Y. K. Tyagi, Guar gum based edible coating on cucumber (*Cucumis sativus l.*), *EJPMR*, 2016, *3*(9): 558-570.

27. C. O. Adetunji, A. E1. Fadiji and O. O. Aboyeji, Effect of chitosan coating combined *Aloe vera* gel on cucumber (*Cucumis Sativa* L.) post-harvest quality during ambient storage, *JETEAS*, 2014, 5(6): 391-397.

28. A. P. Medlicotte, J. M. Sigrist, S. B. Reynolds and A. K. Thompson, Effect of ethylene and acetylene on mango fruit ripening, *J Applied Biol*,1987, 111: 439-444.

29. G. B. Seymour, K. Manning, J. E. Taylor and G. A. Tucken, *Soft fruits* In: Seymour G. B, Taylor J. E, Tucken G. A. (Eds.). Biochemistry of Fruit Ripening Chapman & Hall, London, UK; 1993, 347-373

30. O. Yaman and L. Bayoindirli, Effects of an edible coating and cold storage on shelf-life and quality of cherries, *Lebnsm. Wiss. Und. Technol*, 2002, *35*: 46-150.

31. D. K. Salunkhe, H. R. Boun and N. R. Reddy, *Storage processing and nutritional quality of fruits and vegetables*, In. Fresh Fruits Veg; Boston: CRC Press Inc,1991.

32. S. M. Smith and J. R. Stow, The potential of a sucrose ester coating material for improving the storage and shelf-life qualities of Cox's Orange Pippin apples, *Annals of Applied Biology*. *1984*, 104: 383-391.

33. C. Ozden and L. Bayindirli, Effects of combinational use of controlled atmosphere, cold storage and edible coating applications on shelf life and quality attributes of apples, *Euro. Food Res. Tech.*, 2002, *214*: 320–26.

34. T. Bourtoom, Factor Affecting the Properties of Edible Film Prepared from Mung Bean Proteins, *International Food Research Journal*, 2008, 15(2): 167-180.

35. O. S. Omoba and U. Onyekwere, Postharvest physicochemical properties of cucumber fruits (*Cucumber sativus* L) treated with chitosan-lemon grass extracts under different storage durations, *Afr. J. Biotechnol.*,2016, 15(50): 2758-2766.

36. S. M. Ibrahim, S. Nahar, J. M. M. Islam, M. Islam, M. M. Hoque, R. Huque and M. A. Khan, Effect of low molecular weight chitosan coating on physico-chemical properties and shelf life extension of pineapple (*Ananas sativus*), *J. For. Prod. Ind*., 2014, *3*(3):161-166.

37. K. Hong, J. Xie, L. Zhang, D. Sun and D. Gong, Effects of chitosan coating on postharvest life and quality of guava (*Psidium guajava* L.) fruit during cold storage, *Sci. Hortic.*,2012, 44: 172-178.

38. E. M. Yahia, M. I. El-Tamzini, A. A. F. El-Saiedm and S. E. D. Al-Yateem, *Training manual on postharvest handling and marketing of horticultural commodities*, FAO, Cairo, Egypt, 2008.

39. F. Al-Juhaimi, K. Ghafoor and E. E. Babiker, Effect of gum arabic edible coating on weight loss, firmness and sensory characteristics of cucumber (C*ucumis sativus* L.) fruit during storage, *Pak. J. Bot*., 2012, 44(4): 1439-1444.

40. P. Zapotoczny and M. Markowski, Influence of hypobaric storage on the quality of greenhouse cucumbers, *Bulg. J. Agric. Sci.*, 2014, 20(6): 1406-1412.

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