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STUDIES ON THE EFFECT OF DIFFERENT EDIBLE COATING ON PHYSIOCHEMICAL PROPERTIES OF STRAWBERRY FRUIT (*FRAGARIA × ANANASSA* DUCH.)

Uday Raj Gaurav*[1], Arvind Kumar[1], Satya Prakash[1], Govind Vishkarma[1], Purnima Gautam[2], Amit Kumar[3], Arbaj Ali[1] and Amit Kumar[1]

[1]Department of Fruit Science, College of Horticulture, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut-250110 Uttar Pradesh, India
[2]Department of Horticulture, Brahmanand P.G. College, Rath-210431 Hamirpur Uttar Pradesh, India
[3] Department of Fruit Science, College of Horticulture, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur 208002 Uttar Pradesh, India
*Corresponding author E-mail: udayrajgauravmzp22@gmail.com
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ABSTRACT

In this study, the effect of different edible coating on the shelf life of strawberry fruit were evaluated, with the aim of extending the shelf life of strawberry fruits while preserving the qualitative characters of the fruit. This investigation was carried out at Postharvest Laboratory of College of Horticulture, Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India in the year 2024-2025. In particular, the application of edible coating enriched with chitosan (1%,1.5% & 2%), Bergamot Essential Oil (BEO) (0.1%, 0.15% & 0.2%), (BEO 0.1% + Citrus pomace 2.5%) & (BEO 0.1% + Citrus pomace 5%) on strawberry fruits was evaluated for their physico-chemical properties, during storage period (up to 10 days) at refrigerated temperature. Moreover, a control test (without coating) was considered. The strawberry treated with BEO 0.1%, showed the best maintenance of the qualitative parameters of the strawberries after 10 days storage followed by strawberries treated with Chitosan 1.5%, showing lower decay rates (14.44 % & 37.78 %), lower weight loss of (8.20% & 12.10%) & maximum fruit color retention (7.10 % & 5.30 %), aroma (7.00 % & 6.00 %) among all the treatment.

Keywords **:** Edible coating, Bergamot essential oil, Citrus pomace, Chitosan, Strawberry.

Introduction

The strawberry (*Fragaria* × *ananassa* Duch.) is a widely grown man made hybrid plant cultivated worldwide for its fruit. The genus *Fragaria*, the strawberries, is in the rose family, Rosaceae. The fruit is appreciated for its aroma, bright red colour, juicy texture and sweetness. It is eaten either fresh or in prepared foods such as jam, ice cream and chocolates. Strawberry belongs to native of subtropical climate, are currently grown almost everywhere in the world, from temperate to tropical and subtropical countries. Strawberry is nutrient rich fruit as a source of various bioactive compounds because of its high levels of vitamin C content, folate and phenolic constituent (Farida *et al.,* 2023). Strawberry is one of the most liked fruits in the world due to its pleasant color, shape and aroma (Hu *et al.,* 2012). Strawberry, being a nutritive fruit crop containing high phytochemicals, vitamins and minerals is highly perishable non-climacteric fruit due to its high rate of respiration, leading to a shorter shelf life after harvesting (Almenar *et al.,* 2007), Total postharvest losses of fruits and vegetables range from 25 to 40% in various countries, rising up to 60% in perishable commodities in developing countries that cause a huge financial loss to farmers (Ahmed *et al.,* 2013). Therefore, for extending the postharvest life of strawberry fruits, many preservation techniques are being used that includes hot water treatment (Villa-Rojas *et al.,* 2011),

irradiation (Jouki and Khazaei, 2014), hypobaric storage (Hashmi *et al.,* 2013), chemical treatments (Hu *et al.,* 2012), bio-based packaging (Aday and Caner, 2013), ultrasound technique (Aday *et al.,* 2013) and edible coating (Wang and Gao, 2013). Edible coatings are comprised of edible compounds such as lipids, proteins and polysaccharides and can be consumed as a part of food (Cagri *et al.,* 2004; Fakhouri *et al.*, 2015). These coatings enhance shelf life of food commodities by refining their internal atmosphere. These act as a semipermeable barrier and reduce respiration and transpiration rates and hence retards senescence (Gao *et al.,* 2015). Chitosan, the N-deacetylated derivative of chitin, mainly found in shrimp skeleton and recognized as safe by U.S. FDA (2001). Chitosan has potential in controlling plant disease (Kumar, 2000) including activity against infection caused by bacteria, mould and other pathogens (Goy *et al.,* 2009). Besides, Chitosan had shown the antioxidant properties coming from the donation of hydrogen or lone pair of electron from their structure (Rajalakshmi *et al.,* 2013). Chitosan coating have been proved to be applicable for prevention the losses of weight, titratable acidity, total soluble solid and bioactive compounds in fruit and vegetable during storage (Gol *et al.,* 2013; Kerch, 2015).

Bergamot essential oil as an edible coating can improve fruit quality and extend shelf life by reducing weight loss, enhancing antioxidant activity and inhibiting microbial growth. It also helps in maintaining the fruit's firmness and other qualitative parameters during storage.

Material and Methods

The present experiment was carried out at Post harvest laboratory, College of Horticulture of Sardar Vallabhbhai Patel University of Agriculture and Technology, Modipuram, Meerut, Uttar Pradesh, India. Geographically, the experimental laboratory is located at 29˚04' North latitude, 77˚42' East longitude and at an altitude of 237.75 meter above the mean sea level. The treatments included: Control (T1), Chitosan 1% (T2), Chitosan 1.5% (T3), Chitosan 2% (T4), Bergamot Essential Oil 0.1% (T5), Bergamot Essential Oil 0.15% (T6), Bergamot Essential Oil 0.2% (T7), Bergamot Essential Oil 0.1% + Citrus Pomace 2.5% (T8), and Bergamot Essential Oil 0.1% + Citrus Pomace 5% (T9). These treatments were applied to guava fruits under a Completely Randomized Design (CRD) with three replications.

Strawberries were collected from the local fruit market at Meerut city, Uttar Pradesh, India then fruits were immediately transported to the post-harvest laboratory. Fruits were firstly selected on the bases of uniformity of its Shape, Size, Colour and Weight while the other defective ones were discarded. Then the fruits were washed thoroughly with distilled water and was dried under room temperature for approx. one hours. Chitosan Powder of LR Grade was sourced from BFCLAB, Bangalore Fine Chemicals, Bangalore, India. Which was used as an edible coating in this experiment and the Bergamot Essential Oil Was sourced from essential extract, with 100% purity used as an edible coating in the experiment. Citrus Pomace which is the By-product of citrus fruit processing (Mausambi) during juice production Was prepared in the postharvest lab of the university for which the peel, pulp & Seed of citrus fruit was collected from the local juice vendor and was dried in hot air oven for overnight at 50^0 temperatures until reaching to the desired moisture content of 12% and then was grinded to a fine powder.

Coating Preparation and Application to the surface of strawberries

Preparation of chitosan coating

Chitosan Coating Solution (500ml) of each concentration (1%, 1.5%, 2%) was prepared by adding (5, 7.5, 10gm) of chitosan powder to 0.5% acetic acid and than the prepared mixture was added to 500ml of distilled water. The solution was stirred in a magnetic stirrer at room temperature until the chitosan flakes disappear. Afterword, 1gm of glycerol was added as plasticizer to improve the strength and flexibility of the coating solution.

Preparation of Bergamot Essential Oil (BEO) Coating

Bergamot Essential Oil Coating solution of each concentration (0.1%, 0.15%, 0.2%) was prepared by adding (0.5ml, 0.75ml,1ml) of Bergamot Essential Oil of 100% purity to 500ml of distilled water and was stirred in a magnetic stirrer for 1 hrs and than1gm of glycerol was added as plasticizer to improve the strength and flexibility of the coating solution.

Preparation of (BEO + Citrus Pomace) solution

Firstly 0.1% BEO solution was prepared by mixing of 0.5ml of BEO to 500ml of distilled water and then 2.5% citrus pomace which is 12.5 gm of citrus pomace was added to the BEO solution and then was mixed well with the help to stirrer. 1 gm of glycerol was tan added to the solution as a plasticizer to improve the strength and flexibility of the coating solution. Similarly, solution of (BEO 0.1% + citrus pomace5%) was made.

Application and Storage

The strawberries were divided into 8 groups and each group was further subdivided into 3 replications

and each group of fruits were dipped in their respective coating for 2 min. and the control was only dipped in distilled water. After coating application, the fruits were dried in room temperature. The fruits were packed in a transparent plastic box and each box consist of 15 fruits. The boxes were than stored in refrigerator. Fruits were analyzed for their quality from 0-10 day at an interval of 2 days.

Physiological weight loss (PLW)

PLW was determined by the formula of Srivastava and Tandon (1968).

$$\text{PLW}(\%) = \frac{\text{Initial weight} - \text{Final weight}}{\text{Initial weight}} \times 100$$

Decay %

Data on the spoilage will be recorded on the 2nd, 4th, 6th and 8th days of Storage and expressed as percentage based on the appearance of visible symptoms of spoilage and unmarketable shrinkage.

Specific gravity

The soluble solids have a direct dependency on the specific gravity. The greater the soluble solid the more is the specific gravity.

$$\text{Specific gravity} = \frac{\text{the volume of water was displaced when Strawberry was submerged entirely inside water}}{\text{weight of Strawberry in air}}$$

Fruit firmness

Fruit firmness data will be recorded on 2nd, 4th, 6th and 8th day of Storage. Fruit firmness was recorded by penetrometer.

Fruit skin colour

The fruit skin colour will be evaluated for skin by a panel of judges based on physical appearance. Fruit skin colour measured on 2nd, 4th, 6th and 8th day during storage period. The sensory evaluation test will be conducted and rated by Hedonic rating (0-9).

Aroma

Data on the Aroma will be recorded on the 2nd, 4th, 6th and 8th day of Storage. The fruits will be evaluated for aroma by a panel of judges based on physical appearance. The sensory evaluation test will be conducted and rated by Hedonic rating (0-9).

Organoleptic taste

The fruits will be evaluated for organoleptic taste by a panel of judges based on physical appearance. Organoleptic taste of Strawberry fruits will be recorded on the 2nd, 4th, 6th and 8th day of Storage. The sensory evaluation test will be conducted and rated by Hedonic rating (0 9).

Fruit freshness

The fruit freshness of Strawberry fruits was recorded on 2nd, 4th, 6th and 8th day of storage. The fruits will be evaluated for Fruit freshness by a panel of judges based on physical appearance. The sensory evaluation test will be conducted and rated by Hedonic rating (0-9).

Statistical analysis

Statistical analysis of the data was conducted following the standard procedures outlined by Gomez and Gomez (1996). The results revealed a significant enhancement across all measured parameters attributable to the various treatments implemented. The statistical analysis indicated significant differences, as the calculated F value exceeded the tabulated F value, underscoring the effectiveness of the applied treatments. Treatment means were compared using Duncan's Multiple Range Test (DMRT) at a significance level of $p < 0.05$. DMRT was conducted to validate results using XLSTAT 2014.5.03 software, ensuring accuracy and statistical reliability.

Result and Discussion

Physiological loss in Wight (PLW)

Weight loss represents an important parameter that can be used to evaluate the quality of the fruits as it reflects underlaying physiological processes such as transpiration and respiration. Strawberries are highly perishable fruit due to its thin epidermal layer which makes them especially vulnerable. As a result, water loss leads to tissue contraction and weakening, negatively affecting the fruit's appearance, texture, colour, aroma and shelf life which causes economic losses. Edible coating serves as a protective barrier against the external environment, primarily by reducing transpiration and delaying dehydration. This barrier function helps in minimizing weight loss and maintaining the fruit's quality over time.

In this study, the percentage of weight loss progressively increased in all the treatments throughout the storage period. The data presented in table – 2 regarding physiological weight loss under different treatment showed statistically significant effect throughout the observation period, indicating the effectiveness of certain coating in slowing down weight loss.

Decay Percentage

The decay percentage of the stored fruits showed a gradual increase with the advancement of storage period. This is a common trend observed due to increased microbial activity, senescence and

breakdown of tissue integrity over time. In this study the decay percentage gradually increases at the time storage in all the treated strawberry the lowest decay percentage was recorded 14.44 on the 10th day to storage in the strawberry treated with BEO 0.1% followed by 37.78 % in the strawberry treated with Chitosan 1.5% While the highest decay percentage was recorded 66.66 % in the strawberry without any treatment (Control) followed by 62.22 % in strawberry treated with BEO 0.15% and strawberry treated with BEO 0.1% + Citrus pomace 5% each. Hence, the above data showed that BEO 0.1% has the highest capability to reduce the decay percentage of the strawberry fruits.

Specific Gravity

Specific gravity is an important parameter that reflects the density of the fruit or vegetable relative to water. It is often used as an indirect indicator of maturity, dry matter content and internal quality. In this study the specific gravity gradually decreases at the time of storage in all the treatment, the highest specific gravity was recorded 1.27 on the 10th day of storage in the strawberry treated with BEO 0.1% and strawberry treated with BEO 0.15% followed by 1.24 in strawberry treated with Chitosan 1.5% while the lowest specific gravity 0.81 was recorded in the strawberry without any treatment (Control).

Fruit firmness

Fruit firmness is a critical quality attribute that determines the marketability, consumer acceptability and shelf life of horticultural produce. It is influenced by various physiological processes such as ripening, water loss and enzymatic degradation of the cell wall during storage. In this study strawberry treated with BEO 0.1% shows the highest maintenance of the fruit firmness with the highest firmness value of 1.79 on the 10th day of storage followed by strawberry treated with BEO 0.1% + Citrus pomace 2.5% with a firmness value of 1.48 while the lowest value of firmness 1.34 was recorded in strawberry with no treatment (Control).

Fruit skin colour

Skin colour is one of the most important visual and quality parameters that directly influences consumer preference and marketability of fruits. It also reflects the ripening stage, pigment development and physiological condition of the fruit. In this study a gradual change in skin colour was observed in all treatments as storage progressed. The strawberry treated with BEO 0.1% shows the best maintenance of fruit skin colour on the 10th day of storage with the highest rating value of 7.10 followed by the strawberry treated with Chitosan 1.5% with a rating of 5.30 while the lowest maintenance of fruit skin colour 1.00 was recorded in the strawberry without any treatment (Control) followed by strawberry treated with BEO 0.1% + Citrus pomace 5% with a rating of 3.00.

Aroma

Aroma is a vital organoleptic quality of fruits that significantly affects consumer acceptance and perceived freshness. It is primarily influenced by the synthesis and release of volatile organic compounds (VOCs), which are closely linked to fruit ripening, enzymatic activity and storage conditions. In this study the results showed that aroma intensified progressively with the advancement of storage time across all treatments, the highest value of aroma was recorded in the strawberry treated with BEO 0.1% with a value of 7.00 on the 10th day of storage followed by strawberry treated with Chitosan 1.5% with a value of 6.00 while the lowest aroma 2.00 was observed in the strawberry with no treatment (Control) followed by 3.00 in strawberry treated with BEO 0.1% + Citrus Pomace 5%.

Organoleptic Taste

Organoleptic taste, or sensory taste evaluation, is a crucial quality parameter reflecting the overall palatability, sweetness, acidity and flavor balance of fruits. It directly influences consumer satisfaction and market value and is shaped by biochemical changes occurring during storage, such as sugar accumulation, acid degradation and aroma compound synthesis. In this study the results showed a significant variation in taste scores across treatments and days of storage. The strawberry treated with BEO 0.1 % showed the best maintenance of the flavours and taste at the 10th day of the storage period with a rating of 7.00 followed by strawberry treated with Chitosan 1.5% , BEO 0.15%, 0.2 % and BEO 0.1% + Citrus pomace 2.5% with a rating of 5.00 each while the strawberry without any treatment shows the lowest maintenance of the flavour and taste with a value of 1.00.

Freshness

Freshness is a key quality attribute that encompasses visual appearance, firmness, aroma, colour and overall acceptability, influencing consumer appeal and marketability. It serves as an indirect measure of postharvest physiological status, including moisture retention, ripening stage and microbial decay. In this study the results indicated that freshness gradually declined with increasing storage duration across all treatments, the strawberry treated with BEO 0.1% shows the best maintenance of the freshness with a value of 7.00 followed by strawberry treated with

Chitosan 1.5% with a value of 5.00 while the lowest maintenance was showed by the strawberry without any treatment (Control) with the value of 1.00 followed by strawberry treated with BEO 0.15 % with a value of 3.00.

Discussion

Physiological loss in Wight (PLW)

The control treatment (T1), which received no coating, consistently exhibited the highest PLW across all storage interval, stating at 5.20% on the 2nd day of storage and reaching a substantial 31.70% by the 10th day of the storage clearly indicating rapid loss in moisture and deterioration in the quality of the fruit. On the other hand, strawberry treated with BEO 0.1% showed the lowest PLW (0.50% on the 2nd day of storage and 8.20% on the 10th day of storage), followed closely by strawberry treated with chitosan 1.5% (0.80% on the 2nd day of storage and 12.10%$ on the 10th day of storage). Similar outcomes were reported by Nguyen *et al*. (2020),

where strawberries coated with chitosan retained higher moisture level and showed significantly lower PLW throughout storage. Additionally, De Bruno *et al*. (2023) found that edible coating enriched with natural antioxidants and Bergamot Essential Oil limited PLW to below 12% even after 14 days.

Decay Percentage

The strawberry without any treatment (control) (T_1) recorded the highest decay throughout the storage period, escalating from 2.22% on the 2nd day of the storage to a substantial 66.66% by the 10th day of the storage, highlighting its rapid deterioration due to microbial spoilage. In contrast, strawberry treated with BEO 0.1% T_5 consistently maintained the lowest decay rates at all intervals remaining as low as 2.22% on the 4th day of storage and reaching only 14.44% by the 10th day of storage followed by strawberry treated with chitosan 1.5% T_3 showing relatively good performance, ending with decay percentages of 37.78% by the 10th day of storage. Valenzuela *et al*. (2015) demonstrated that edible films composed of chitosan, quinoa protein, and sunflower oil significantly reduced fungal decay in strawberries and extended their shelf life up to 15 days with minimal mold growth. Similarly, De Bruno *et al*. (2023) reported that strawberries coated with bergamot essential oil exhibited final decay percentages of only 27–36%, consistent with the performance seen in T_5.

Specific Gravity

The strawberry without any treatment (control) (T_1) consistently recorded the lowest specific gravity, dropping from 0.88 on the 2nd day of storage to 0.81 by the 10th day of storage, reflecting greater weight loss and deterioration. In contrast, treatments such as BEO 0.1% (T5) and Chitosan 1.5% (T3), maintained high and even increasing specific gravity over time strawberry treated with chitosan 1.5% rose from 1.14 on the 2nd day of storage to 1.24 on the 10th day of storage, while strawberry treated with BEO 0.12% (T_5) reached 1.27 by the 10th day of storage. These findings are supported by Nguyen *et al*. (2020), who reported that strawberries coated with nano-chitosan retained higher firmness and weight, resulting in improved density and overall quality during storage. Similarly, De Bruno *et al.* (2023) observed that coatings enriched with bergamot essential oil preserved fruit structure and minimized shrinkage, thereby contributing to higher density over time.

Fruit firmness

The strawberry without any treatment (control) (T_1) showed the steepest decline, dropping from 1.70 on the 2nd day of storage to 1.34 on the 10th day of storage, indicating rapid softening. In contrast, strawberry treated with BEO 0.1% T_5 consistently maintained the highest firmness, starting at 1.98 on the 2nd day of storage and retaining 1.79 even at the 10th day of storage, suggesting strong protection against tissue degradation. Strawberry treated with Chitosan 1.5% T_3, also preserved firmness better than the control, maintaining values around 1.41 on the 2nd day of storage to 1.48 by the 10th day of storage. These results align closely with the findings of Nguyen *et al*. (2020), who observed that strawberries treated with chitosan coatings retained significantly higher firmness due to reduced respiration and moisture loss. Similarly, De Bruno *et al.* (2023) reported that coatings containing bergamot essential oil successfully delayed softening, with coated strawberries showing firmness values around 5–6 after 14 days of storage.

Fruit skin colour

The control (T_1) exhibited the fastest and most severe loss in skin colour, decreasing from 8.10 on the 2nd day of storage to just 1.00 by the 10th day of storage, reflecting significant deterioration in visual quality. In contrast, Strawberry treated with BEO 0.1% T_5 maintained the highest skin colour values throughout, declining only slightly from 9.10 on the 2nd day of storage to 7.10 by the 10tyh day of storage. Strawberry treated with Chitosan 1.5% T_3 also

performed well, preserving more vibrant skin colour by the 10th day of storage compared to the control and most other treatments. This trend aligns with findings from De Bruno *et al*. (2023), where strawberries coated with bergamot essential oil maintained better surface colour (hue and chroma). Additionally, Nguyen *et al*. (2020) demonstrated that chitosan coatings helped preserve colour intensity by reducing enzymatic browning and anthocyanin oxidation.

Aroma

The control (T_1) showed the sharpest decline, dropping from a high of 9.00 on the 2nd day of storage to just 2.00 by the 10th day of storage, indicating a major loss of organoleptic appeal. On the other hand, Strawberry treated with BEO 0.1% T_5 consistently retained the highest flavour/aroma scores, maintaining a rating of 7.00 even on the 10th day of storage, suggesting strong preservation of freshness. Strawberry treated with Chitosan 1.5% T_3 also performed well, ending with scores of 6.00 on the 10th day of storage, much higher than the control. These results are supported by the findings of Valenzuela *et al*. (2015), who showed that coatings made with chitosan, quinoa protein, and sunflower oil effectively preserved aroma and delayed off-flavour development in strawberries up to 15 days. Similarly, De Bruno *et al*. (2023) reported that strawberries treated with bergamot essential oil maintained acceptable sensory quality, including aroma, for up to two weeks, while uncoated fruits rapidly lost consumer acceptability

Organoleptic Taste

The control treatment (T_1) showed the steepest decline, from a score of 8.00 on the 2nd day of storage to just 1.00 on the 10th day of storage, indicating complete loss of consumer acceptability. In contrast, Strawberry treated with BEO 0.1% T_5 consistently recorded the highest scores, maintaining a near-fresh taste throughout storage starting at 9.00 on the 2nd day of storage and still retaining 7.00 by the 10th day of storage. Other treatments such as strawberry treated with chitosan 1.5% T_3, also performed well, showing gradual but more controlled declines compared to the control. These findings are supported by De Bruno *et al*. (2023), who found that strawberries coated with bergamot essential oil retained acceptable sensory quality including taste for up to 14 days, while control fruits dropped below the acceptable threshold by day 10. Likewise, Valenzuela *et al*. (2015) reported that a composite film of chitosan, quinoa protein, and sunflower oil preserved the organoleptic profile of strawberries by forming a protective barrier that slowed down dehydration and microbial growth.

Freshness

The control treatment (T_1) showed the most rapid deterioration, dropping from a freshness score of 7.00 on the 2nd day of storage to just 1.00 by the 10th day of storage, indicating complete loss of visual appeal and marketability. In contrast, Strawberry treated with BEO0.1% T_5 maintained the highest freshness scores throughout, starting at 9.00 on the 2nd day of storage and remaining at 7.00 even after the 10th day of storage of storage demonstrating excellent preservation. Treatments such as chitosan 1.5% T_3, also performed notably well, maintaining scores of 5.00 by the 10th day of storage. These results strongly support findings by De Bruno *et al*. (2023), who reported that strawberries coated with bergamot essential oil retained superior freshness, appearance, and consumer acceptability throughout extended storage. Additionally, Valenzuela *et al*. (2015) found that a biofilm composed of chitosan, quinoa protein, and sunflower oil effectively preserved the visual freshness and surface texture of strawberries by reducing water loss and microbial decay.

Conclusion

This study revealed that the After 10^{th} day of storage the strawberry that shows the best qualitative characteristics were those coated with BEO 0.1% and chitosan 1.5%. for these treatments lower decay rates were recorded (14.44 & 37.78), with better acceptability from sensory and textural point of view with (fruit colour score 7.10, aroma score 7.00, organoleptic taste score 7.00 & freshness score 7.00 for strawberry treated with BEO 0.1% and fruit colour score 5.30, aroma score 6.00, organoleptic taste score 5.00 & freshness score 5.00 for strawberry treated with Chitosan 1.5%) as well as showing good maintenance of titrable acidity, total sugar and reducing sugar. Hence from the above study we conclude that the Treatment T5 BEO 0.1% shows the best maintenance of the physio-chemical parameters of the strawberry fruit followed by Chitosan 1.5%.

Table 1 : Effect of different physico-chemical treatments on PLW, Decay % and Specific Gravity during storage of strawberry fruit

Treatment	Physiological Weight Loss (Day 2)	Physiological Weight Loss (Day 4)	Physiological Weight Loss (Day 6)	Physiological Weight Loss (Day 8)	Physiological Weight Loss (Day 10)	Decay Percentage (Day 2)	Decay Percentage (Day 4)	Decay Percentage (Day 6)	Decay Percentage (Day 8)	Decay Percentage (Day 10)	Specific Gravity (Day 2)	Specific Gravity (Day 4)	Specific Gravity (Day 6)	Specific Gravity (Day 8)	Specific Gravity (Day 10)
T1	5.203±[a]	9.400±a	13.117±a	23.697±a	31.700±a	2.217±a	11.107±b	22.223±b	31.107±d	66.663±a	0.883±f	0.877±e	0.857±e	0.843±f	0.813±e
T2	4.200±[c]	8.020±b	11.397±b	14.057±c	18.090±c	0.000±b	4.440±e	11.107±f	35.553±b	46.663±c	1.020±d	1.013±c	0.980±d	0.967±e	0.920±d
T3	0.797±[h]	2.197±e	3.100±g	8.417±f	12.097±f	0.000±b	6.657±d	15.553±e	26.663±f	37.777±f	1.140±b	1.167±a	1.170±b	1.210±ab	1.240±a
T4	4.897±[b]	7.317±c	11.040±c	15.000±b	19.213±b	0.000±b	15.553±a	19.997±c	33.333±c	44.443±b	2.057±a	1.120±b	1.317±a	1.177±bc	1.193±b
T5	0.500±[i]	1.100±h	1.500±h	5.207±i	8.197±i	0.000±b	2.220±f	8.883±g	11.107±g	14.443±i	1.090±c	1.117±b	1.177±b	1.233±a	1.273±a
T6	1.000±g	1.500±g	3.697±f	6.897±h	14.803±h	0.000±b	15.553±a	24.443±a	39.997±a	62.220±h	1.090±c	1.117±b	1.177±b	1.233±a	1.273±a
T7	1.217±f	1.700±f	3.897±f	7.780±g	14.697±g	0.000±b	8.880±c	17.773±d	31.107±d	42.220±g	0.947±e	0.947±d	0.940±d	0.943±e	0.917±d
T8	4.020±d	7.897±b	10.073±d	13.097±e	17.040±e	0.000±b	11.107±b	17.777±d	28.883±e	42.220±e	1.073±c	1.103±b	1.110±c	1.120±d	1.127±c
T9	2.497±e	3.197±d	8.777±e	13.537±d	19.273±d	2.217±a	15.557±a	24.443±a	39.997±a	62.220±d	1.093±c	1.110±b	1.133±bc	1.143±cd	1.133±c
Gen. Mean	**2.703**	**4.703**	**7.400**	**11.965**	**17.234**	**0.493**	**10.119**	**18.022**	**30.861**	**46.541**	**1.155**	**1.063**	**1.096**	**1.097**	**1.099**
C.V.	1.852	1.856	1.941	1.841	2.730	2.408	1.831	1.764	2.489	2.616	2.014	1.966	2.409	2.220	1.902
S.E.M.	0.029	0.050	0.083	0.127	0.272	0.007	0.107	0.184	0.443	0.703	0.013	0.012	0.015	0.014	0.012
C.D. 5%	0.086	0.150	0.246	0.378	0.807	0.020	0.318	0.545	1.318	2.088	0.040	0.036	0.045	0.042	0.036

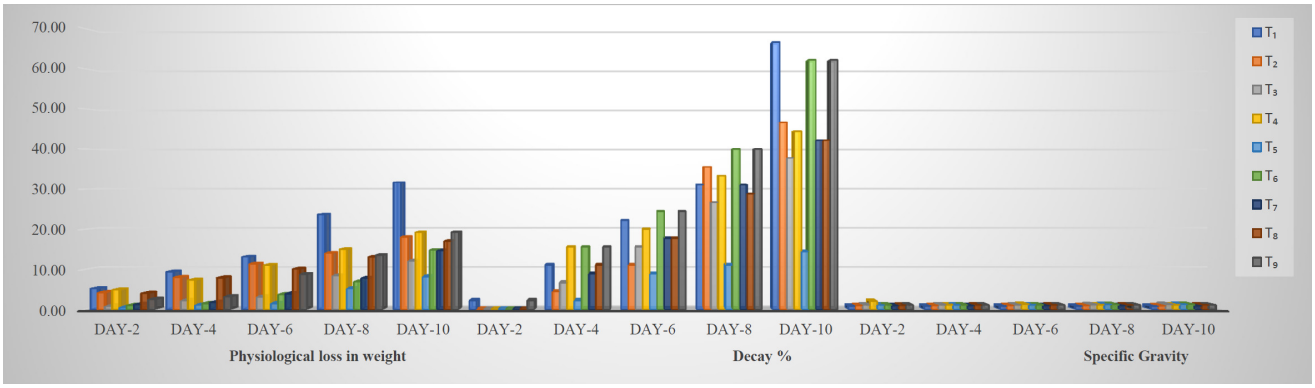

Fig. 1 : Effect of different physico-chemical treatments on PLW, Decay % and Specific Gravity during storage of strawberry fruit

Table 2 : Effect of different physico-chemical treatments on Fruit firmness, Fruit skin colour and Flavour/Aroma during storage of strawberry.

Treatment	Fruit Firmness (Day 2)	Fruit Firmness (Day 4)	Fruit Firmness (Day 6)	Fruit Firmness (Day 8)	Fruit Firmness (Day 10)	Fruit Skin Color (Day 2)	Fruit Skin Color (Day 4)	Fruit Skin Color (Day 6)	Fruit Skin Color (Day 8)	Fruit Skin Color (Day 10)	Flavour/Aroma (Day 2)	Flavour/Aroma (Day 4)	Flavour/Aroma (Day 6)	Flavour/Aroma (Day 8)	Flavour/Aroma (Day 10)
T1	1.700±ef	1.637±c	1.507±e	1.477±c	1.340±e	8.103±e	6.300±e	5.200±g	2.100±f	1.000±g	8.997±a	7.000±b	6.000±c	4.000±d	2.000±f
T2	1.937±ab	1.877±a	1.647±bc	1.500±c	1.340±e	9.397±ab	8.397±b	6.297±e	5.197±cd	3.100±f	8.997±a	7.000±b	6.003±c	5.003±c	4.000±d
T3	1.817±cd	1.703±b	1.613±c	1.503±c	1.410±c	9.200±bc	7.600±c	6.600±d	5.300±c	5.300±b	9.000±a	8.000±a	7.000±b	7.000±a	6.003±b
T4	1.873±bc	1.720±b	1.657±bc	1.400±d	1.380±d	8.400±d	8.300±b	6.197±ef	5.100±d	4.100±d	8.000±b	7.000±b	6.003±c	5.000±c	4.997±c
T5	1.977±a	1.907±a	1.867±a	1.817±a	1.790±a	9.100±c	9.003±a	8.197±a	7.300±a	7.100±a	8.997±a	8.000±a	8.000±a	7.000±a	6.997±a
T6	1.817±cd	1.703±b	1.613±c	1.503±c	1.410±c	9.300±abc	8.100±c	7.400±b	6.100±b	5.100±c	9.000±a	8.000±a	6.000±c	6.003±b	5.000±a
T7	1.717±ef	1.687±bc	1.610±cd	1.517±c	1.410±c	8.200±de	7.200±c	6.100±f	5.200±cd	3.297±e	9.000±a	7.000±b	6.000±c	5.000±c	4.000±e
T8	1.777±de	1.707±b	1.677±b	1.607±b	1.480±b	9.500±a	8.400±b	7.197±c	6.200±b	5.200±bc	7.997±b	8.000±a	7.000±b	6.000±b	5.000±d
T9	1.697±f	1.643±c	1.563±d	1.507±d	1.370±d	8.200±de	7.303±d	6.100±f	4.000±e	3.000±f	9.000±a	7.000±b	6.000±c	5.000±c	3.000±d
Gen. Mean	**1.812**	**1.731**	**1.639**	**1.537**	**1.437**	**8.822**	**7.845**	**6.587**	**5.166**	**4.133**	**8.776**	**7.444**	**6.445**	**5.556**	**4.555**
C.V.	2.573	1.912	1.769	2.330	1.206	1.603	2.264	1.726	1.576	2.220	1.830	2.524	2.546	2.136	2.397
S.E.M.	0.027	0.019	0.017	0.021	0.010	0.082	0.103	0.066	0.047	0.053	0.093	0.108	0.095	0.069	0.063
C.D. 5%	0.080	0.057	0.050	0.061	0.030	0.243	0.305	0.195	0.140	0.157	0.276	0.322	0.281	0.204	0.187

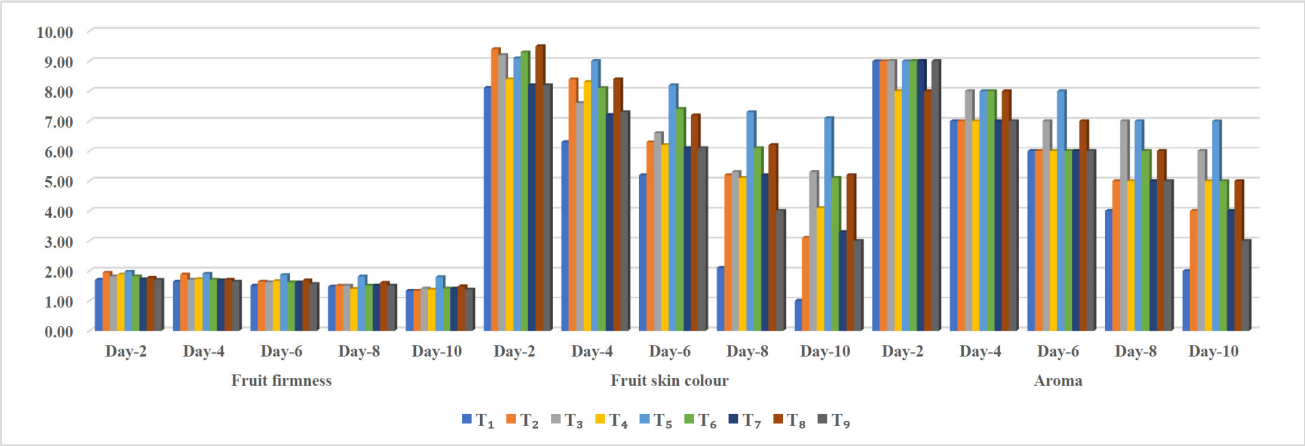

Fig. 2 : Effect of different physico-chemical treatments on Fruit firmness, Fruit skin colour and Flavour/Aroma during storage of strawberry fruit

Table 3 : Effect of different physico-chemical treatments on Organoleptic Taste and Fruit freshness during storage of strawberry

Treatment	Organo-leptic Taste (Day 2)	Organo-leptic Taste (Day 4)	Organo-leptic Taste (Day 6)	Organo-leptic Taste (Day 8)	Organo-leptic Taste (Day 10)	Freshness (Day 2)	Freshness (Day 4)	Freshness (Day 6)	Freshness (Day 8)	Freshness (Day 10)
T1	8.000±b	5.997±c	5.000±d	3.000±e	1.000±e	7.000±c	5.997±c	4.000±e	3.000±e	1.000±e
T2	8.000±b	7.000±b	7.000±b	5.000±c	3.997±c	8.000±b	7.000±b	7.000±b	5.003±c	4.000±c
T3	8.000±b	6.000±c	6.000±c	5.000±c	5.000±b	9.000±a	8.000±a	8.000±a	6.000±b	5.000±b
T4	8.000±b	7.000±b	5.000±d	5.000±c	4.003±c	8.000±b	7.000±b	4.997±d	5.000±c	4.000±c
T5	9.000±a	7.997±a	7.997±a	8.000±a	7.000±a	9.000±a	8.000±a	8.000±a	8.000±a	7.000±a
T6	9.003±a	8.000±a	7.000±b	5.000±c	5.000±b	8.003±b	5.997±b	4.997±d	4.000±b	3.000±b
T7	8.000±b	6.997±b	6.000±c	6.000±b	5.000±b	9.000±a	8.000±a	6.000±c	5.000±b	5.000±b
T8	8.000±b	7.000±b	7.000±b	6.000±b	5.000±b	8.000±b	6.997±b	6.000±c	5.000±b	5.000±b
T9	8.000±b	5.997±c	5.000±d	4.000±d	2.000±d	8.003±b	5.997±b	5.000±d	4.000±d	3.003±d
Gen. Mean	**8.223**	**6.887**	**6.222**	**5.222**	**4.222**	**8.223**	**6.999**	**5.999**	**5.000**	**4.111**
C.V.	2.459	1.484	2.236	1.701	2.477	1.699	1.694	1.890	1.916	2.343
S.E.M.	0.117	0.059	0.080	0.051	0.060	0.081	0.068	0.065	0.055	0.056
C.D. 5%	0.347	0.175	0.239	0.152	0.179	0.240	0.203	0.195	0.164	0.165

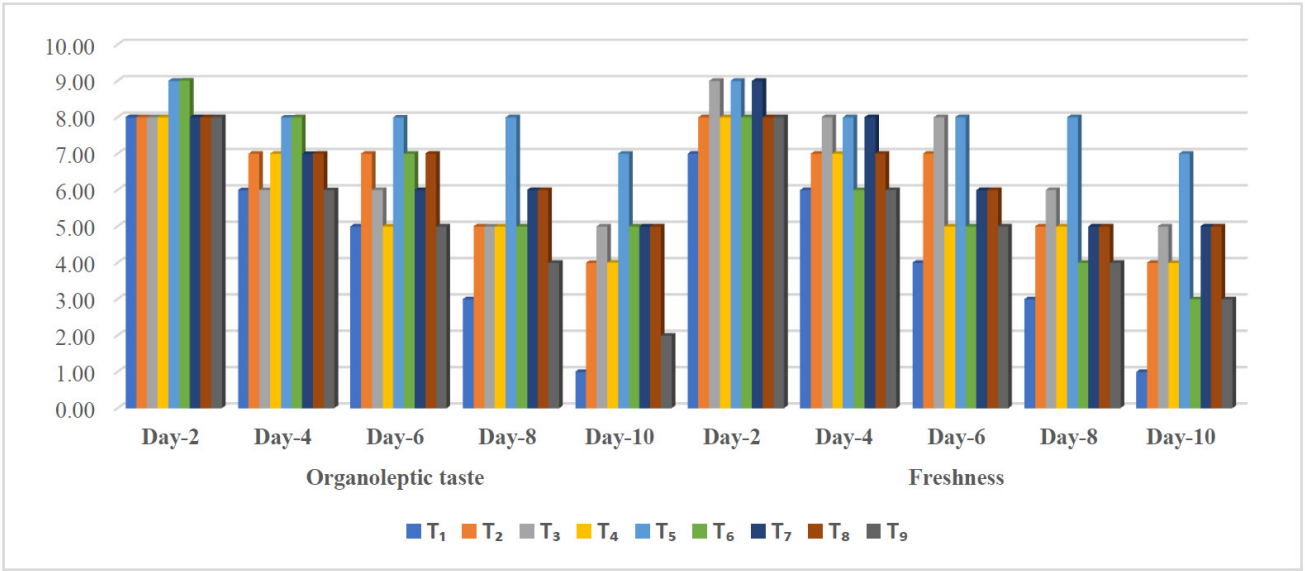

Fig. 3 : Effect of different physico-chemical treatments on Organoleptic Taste and Fruit freshness during storage of strawberry

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Conflict of Interest

The authors declare no competing interests.

References

Aday, M.S., Temizkan, R., Büyükcan, M.B. and Caner, C. (2013). An innovative technique for extending shelf life of strawberry: Ultrasound. LWT-*Food Science and Technology*, **52**: 93-101.

Ahmed, W., Butt, M.S., Sharif, M.K. and Shahid, M. (2013). Comparative estimation of alginate and soy-based coatings on pH and vitamin C contents of strawberry (*Fragaria ananassa*) at controlled climate chamber. *Journal of Food Process and Technology*, **4(11)**: 280.

Almenar, E., Del-Valle, V., Hernández-Muñoz, P., Lagarón, J. M., Catalá, R., & Gavara, R. (2007). Equilibrium modified atmosphere packaging of wild strawberries. *Journal of the Science of Food and Agriculture*, ***87*(10)**, 1931-1939.

Cagri, A., Ustunol, Z. and Ryser, E.T. (2004). Antimicrobial edible films and coatings. *Journal of Food Protection*, **67**: 833-848.

De Bruno, A., Gattuso, A., Ritorto, D., Piscopo, A., & Poiana, M. (2023). Effect of edible coating enriched with natural antioxidant extract and bergamot essential oil on the shelf life of strawberries. *Foods*, **12**(3), 488

Fakhouri, F.M., Martelli, S.M., Caon, T., Velasco, J.I. and Mei, L.H.I. (2015). Edible films and coatings based on starch/gelatin: Film properties and effect of coatings on quality of refrigerated Red Crimson grapes. *Postharvest Biology and Technology*, **109**: 57-64.

Farida, F., Hamdani, J. S., Mubarok, S., Akutsu, M., Noviyanti, K., & Nur Rahmat, B.P. (2023). Variability of strawberry fruit quality and shelf life with different edible coatings. *Horticulturae*, ***9*(7),** 741.

Gao, C.L., Ding, Y., Li, J.H., Wang, Z.H., Han, D.W. and Xia, Y.Z. (2015). Composite solution of tea polyphenols and sodium alginate for coating preservation of strawberries. *Advance Journal of Food Science and Technology*, **9(8)**: 651-657.

Gol, N. B., Patel, P. R., & Rao, T. R. (2013). Improvement of quality and shelf-life of strawberries with edible coatings enriched with chitosan. *Postharvest Biology and Technology*, **85**, 185-195.

Gomez, A.K. and Gomez, A.A. (1996). *Statistical Procedure for Agricultural Research*. 2 John willey and sons pnc. New York.

Goy, R. C., Britto, D. D., & Assis, O. B. (2009). A review of the antimicrobial activity of chitosan. *Polímeros*, **19**, 241-247.

Hashmi, M.S., East, A.R., Palmer, J.S. and Heyes, J.A. (2013). Pre-storage hypobaric treatments delay fungal decay of strawberries. *Postharvest Biology and Technology*, **77**: 75-79.

Hu, L.Y., Hu, S.L., Wu, J., Li, Y.H., Zheng, J.L., Wei, Z.J., Liu, J., Wang, H.L., Liu, Y.S. and Zhang, H. (2012). Hydrogen sulfide prolongs postharvest shelf life of strawberry and plays an antioxidative role in fruits. *Journal of Agricultural and Food Chemistry*, **60**, 8684-8693.

Jouki, M. and Khazaei, N. (2014). Effect of low-dose gamma radiation and active equilibrium modified atmosphere packaging on shelf life extension of fresh strawberry fruits. *Food Packaging and Shelf Life*, **1**: 49-55.

Kerch, G. (2015). Chitosan films and coatings prevent losses of fresh fruit nutritional quality: A review. *Trends in Food Science & Technology*, **46(2)**, 159-166.

Kumar, M. N. R. (2000). A review of chitin and chitosan applications. *Reactive and functional polymers*, **46(1)**, 1-27.

Qamar, J., Ejaz, S., Anjum, M. A., Nawaz, A., Hussain, S., Ali, S., & Saleem, S. (2018). Effect of Aloe vera gel, chitosan and sodium alginate based edible coatings on postharvest quality of refrigerated strawberry fruits of cv. Chandler. *Chandler. J. Hortic. Sci. Technol*, **1(8)**.

Rajalakshmi, A., Krithiga, N., & Jayachitra, A. J. M. E. J. S. R. (2013). Antioxidant activity of the chitosan extracted from shrimp exoskeleton. *Middle East J. Sci. Res*, **16(10)**, 1446-1451.

U.S. FDA (2001). Food and Drug Admistration (FDA) of USA.

Valenzuela, C., Tapia, C., López, L., Bunger, A., Escalona, V., & Abugoch, L. (2015). Effect of edible quinoa protein-chitosan based films on refrigerated strawberry (*Fragaria× ananassa*) quality. *Electronic Journal of Biotechnology,* **18**(6), 406-411.

Villa-Rojas, R., López-Malo, A. and Sosa-Morales, M.E. (2011). Hot water bath treatments assisted by microwave energy to delay postharvest ripening and decay in strawberries (*Fragaria* × *ananassa*). *Journal of the Science of Food and Agriculture*, **91**: 2265-2270.

Wang, S.Y. and Gao, H. (2013). Effect of chitosan-based edible coating on antioxidants, antioxidant enzyme system and postharvest fruit quality of strawberries (*Fragaria* × *aranassa* Duch.). *LWT - Food Science and Technology*, **52**(2): 71-79.