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Enhancing the Shelf Life of Palak and Coriander through Modified Atmosphere Packaging under Diverse Storage Environments

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: Green leafy vegetables are renowned for their rich vitamin and mineral content as well as their nutritional value. However, these vegetables are highly perishable due to their accelerated rates of respiration and transpiration. The process of packing and the choice of packaging materials play a crucial role in extending their shelf life. The main aim of this study was to prolong the shelf life of two prominent leafy greens, Palak (*Beta vulgaris L. var. bengalensis*) and Coriander (*Coriandrum sativum L.*), using Modified Atmospheric Packaging (MAP) and various packaging materials.

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Study Design: The study employed an FCRD experimental design with 12 treatments and 3 replications.

Place and Duration of Study: This study was conducted at Department of Vegetable Science, HC&RI, TNAU, Coimbatore during the year 2023.

Methodology: Freshly harvested Palak and Coriander were collected, sorted, and prepared as 250-gram samples. Two packaging materials (LDPE and PP) and three gas compositions (G1, G2, G3) was employed. The vegetables were stored under both ambient (35±5°C) and refrigerated (5°C) conditions and their physiological loss in weight (PLW %) was monitored. The observations were taken every day up to the spoilage of the produce.

Results: According to the research findings, vegetables could remain fresh under ambient storage for up to 4 days and under refrigeration for up to 15 days. In ambient storage conditions, Palak exhibited the longest shelf life in treatment T3 - G_3M_1 (4% O_2, 5% CO_2, LDPE), followed by T5 - G_2M_2 (6% O_2, 5% CO_2, PP). Meanwhile, Coriander showed better shelf life in treatment T2 - G_2M_1 (6% O_2, 5% CO_2, LDPE), followed by T6 - G_3M_2 (4% O_2, 5% CO_2, PP). Under refrigerated storage conditions, Palak exhibited an extended shelf life in treatment T9 - G_3M_1 (4% O_2, 5% CO_2, LDPE), followed by T12 - G_3M_2 (4% O_2, 5% CO_2, PP). For Coriander, the best results were achieved with treatment T12 - G_3M_2 (4% O_2, 5% CO_2, PP), followed by T8 - G_2M_1 (6% O_2, 5% CO_2, LDPE).

Conclusion: Proper packaging and gas composition significantly increased the shelf life of these leafy greens, offering potential benefits for both producers and consumers. Palak had a longer shelf life when stored under refrigerated conditions, up to 14 days, while Coriander could be kept fresh for up to 12 days in the refrigerator. Gas composition G_3 (4% O_2, 5% CO_2) was found to be effective and LDPE was generally the preferred packaging material in extending the shelf life of the vegetables.

Keywords: Ambient; refrigerated; modified atmospheric packaging (MAP); Green leafy vegetables and shelf life.

1. INTRODUCTION

In recent times due to increased health consciousness, leafy greens have gained popularity. These leafy green vegetables are the richest source of calcium and usually low in fat, high in dietary fibre, rich in folic acid, vitamin-C, potassium, and magnesium. These leaves lose their marketability after the harvest because they senesce quickly and have a higher rate of respiration and transpiration. However, because of inappropriate handling techniques, increased water activity, and high rates of respiration, they suffer greatly in terms of post-harvest losses.

Palak (*Beta vulgaris L. var. bengalensis*) is a leafy vegetable that can be eaten in a variety of ways, like fresh, frozen, preserved, chopped, dehydrated, or cooked. It's packed with nutrients, like vitamin A, vitamin C, and potassium, as well as magnesium and manganese. It is also packed with riboflavin and vitamin E, as well as calcium and potassium. It's a great source of dietary fibre, choline, and inositol - all of which help to prevent artery hardening (arteriosclerosis).

Coriander (*Coriandrum sativum* L.) is one of the most widely used spices in the world, providing flavour and aroma to a variety of foods. It has long prehistory of being used in folk medicine in different civilizations [1]. It is high in lipid (petroselinic acid) and essential oil (0.03-2.6%) linalool. It can be found in seeds and aerial parts, and has a range of pharmacological properties, including anti-oxidants, antibiotics, anti-diabetes, antiepileptic, anti-mutagenic, anti-depressants, anti-anxiety, anti-high blood pressure, anti-inflammation, neuroprotective, diuretics.

One of the packaging techniques for enclosing the food and extending the storage life is modified atmosphere packaging (MAP), which has a composition different from that of ambient air. It lowers the fresh product's respiration rate and generally increases shelf life [2]. Produce is protected by packaging, which also has a significant impact on how air moves about the item. This affects how to maintain the relative humidity as well as the temperature of produce throughout storage and transportation. MAP is demonstrated to be a reliable replacement for the costly CA storage and an effective way for preserving food with high quality and nutritional content [3]. As a result, MAP making use of various packing materials offers the possibility of extending postharvest life. Minimum PLW was observed in coriander packed in MAP without perforation [4]. Vegetables shelf life may be increased by altering the composition of the gases around them and storing them cold afterward. In order to maintain a longer shelf life without lowering the quality of the food during storage, it is desirable to use a combination of control environment and low temperature [5]. The weight loss, colour value, chlorophyll content, and beta carotene content of coriander leaves did not significantly change after 20 days [6]. Therefore, the goal of the current study was to increase the shelf life of coriander and palak by using different packaging materials as well as different gas compositions, preserving the quality.

2. MATERIALS AND METHODS

2.1 Sample Preparation

This experiment was conducted at the Department of Vegetable Science as well as in the laboratory of Department of Food processing and engineering, Tamil Nadu Agricultural University, Coimbatore. Plant samples were collected randomly from the research fields of TNAU. Freshly harvested Palak (variety: All green) and Coriander (variety: CO-5) with consistent size, and matured state were used. To get rid of sick and uneven leaves, sorting and grading was carried out manually [7]. Prior to packaging, the samples were washed with potable water and surface dried by placing them in the shade for 15 minutes [8] in order to eliminate all the impurities. Each treatment for both crops was provided with an individual sample weighing precisely 250.00 g, using a Digital weighing balance (model: Essae, DS-252). In total of 24 samples (12 for each crop) according to their treatments were maintained around 20 days.

2.2 Design & Layout of the Experiment

The design of the experiment was FCRD (Factorial completely randomized block design) with 12 different treatments for both the crops (Palak and Coriander). Three different gas compositions i.e., G1 (5% O2, 5% CO2, 90% N2) , G2 (6% O2, 5% CO2, 89% N2) and G3 (4% O2, 5% CO2, 91% N2) , two different packaging materials LDPE (low density poly ethylene) and PP (polypropylene) covers measuring 10 ×12 inch and thickness of around 100 microns were used.

2.3 Storage Environment

2.3.1 Ambient storage (R_1)

Palak and Coriander were packed in different materials and maintained at room temperature in the Food Processing laboratory for storage. The Relative Humidity (RH) ranged from 55% to 65% and the average temperature was 35±5°C.

2.3.1 Cold storage (R_2)

Palak and coriander were kept in cold storage for a predefined period of time -16 days at a temperature of 5°c and 90% relative humidity.

2.4 Physiological Loss in Weight (PLW)

Physiological loss in weight (PLW) as an indicator of freshness and quality of the produce during storage. To assess physiological loss in

Table 1. Table showing the treatments details of the experiment

Treatment	Storage environment	Gas Composition (O_2: CO_2: N_2)	Packaging material
T1 – $R_1G_1M_1$	Ambient	5% O_2, 5% CO_2, 90% N_2	LDPE
T2 – $R_1G_2M_1$	Ambient	6% O_2, 5% CO_2, 89% N_2	LDPE
T3 – $R_1G_3M_1$	Ambient	4% O_2, 5% CO_2, 91% N_2	LDPE
T4 – $R_1G_1M_2$	Ambient	5% O_2, 5% CO_2, 90% N_2	PP
T5 – $R_1G_2M_2$	Ambient	6% O_2, 5% CO_2, 89% N_2	PP
T6 – $R_1G_3M_2$	Ambient	4% O_2, 5% CO_2, 91% N_2	PP
T7 – $R_2G_1M_1$	Refrigerated	5% O_2, 5% CO_2, 90% N_2	LDPE
T8 – $R_2G_2M_1$	Refrigerated	6% O_2, 5% CO_2, 89% N_2	LDPE
T9 – $R_2G_3M_1$	Refrigerated	4% O_2, 5% CO_2, 91% N_2	LDPE
T10 – $R_2G_1M_2$	Refrigerated	5% O_2, 5% CO_2, 90%N_2	PP
T11 – $R_2G_2M_2$	Refrigerated	6% O_2, 5% CO_2, 89% N_2	PP
T12 – $R_2G_3M_2$	Refrigerated	4% O_2, 5% CO_2, 91% N_2	PP

Here, R – Storage environment, G – Gas composition, M – Packaging material weight, the sample was precisely weighed using the digital weighing balance (model: Essae, DS-252) at the beginning of the experiment and then on each subsequent day. PLW measurements were recorded by maintaining the samples in specific temperature and humidity conditions on a daily basis. The physiological loss in weight (PLW) was calculated by deducting the final weight from the initial weight of the samples, dividing by the initial weight, and then expressing the value in percentage [9].

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

2.5 Statistical Analysis

This experiment was laid out in Factorial Completely randomized design (FCRD) with 12 treatments and 3 replications. Furthermore, a thorough analysis of the collected data was carried out using the statistical programmes SPSS software version 22 and GRAPES software version 1.1.0 with suitable packages. Analysis of Variance (ANOVA) was employed at a significance level of 0.1% to detect statistically significant differences among the treatment groups.

3. RESULTS AND DISCUSSION

The change in sample weight over the course of storage was used to calculate the amount of water lost from the fresh leaves. The analysis revealed the difference in physiological weight loss (%) that was seen. The influence of packaging materials and gas composition on the PLW (%) of Palak & Coriander stored under ambient as well as cold environments was evident in the ANOVA table, and was found to be statistically significant at the 0.1% level of significance. Regardless of the original composition of the atmosphere, oxygen level will rapidly decline in Palak leaves packed in different packaging materials [10]. On the third day of storage, all samples in treatments other than T2 and T6 were spoiled in case of Coriander. whereas in Palak, all samples other than T3 and T5 were spoiled after three days of storage in ambient environments. While under cold conditions, samples T1 and T3 spoiled on the 13th day of storage, sample T4 spoiled on the 14th day of storage, and samples from all other treatments spoiled after the 15th day in the case of coriander. However, samples T1 and T5 began to spoil on the 14th day of storage in case of Palak.

3.1 Effect of Packaging Materials and Gas Composition on PLW (%) of Palak Stored at Ambient Conditions

The weight loss during storage ranged from 0.6% to 1.32%. From the Fig. 1, it was clear that treatment T3 resulted in the smallest amount of weight loss followed by T5. When compared to samples packed in PP, LDPE bags showed the least physiological weight loss during the course of a three-day storage period. It might be because LDPE bags transmit water vapour at a lower rate than any other packaging materials [11]. Fresh vegetables that have lost water may become less turbid, lose nutritional value, or change colour in an unfavorable way.

Table 2. Physiological loss of weight (%) of Palak and Coriander under different treatments

Treatment	Palak				Coriander			
T1	1.20				1.84			
T2	1.08				1.41			
T3	0.64				2.01			
T4	1.32				2.23			
T5	0.85				2.45			
T6	0.93				1.67			
T7	0.57				1.20			
T8	0.65				0.38			
T9	0.17				0.62			
T10	0.74				0.46			
T11	0.52				0.41			
T12	0.31				0.30			
	R	**G**	**M**	**RGM**	**R**	**G**	**M**	**RGM**
S. Ed	0.006	0.007	0.006	0.014	0.007	0.008	0.007	0.017
CD	0.012***	0.014 ***	0.012***	0.029***	0.014***	0.017***	NS	0.034***

*Here, R – Storage environment, G – Gas composition, M – Packaging material; *** Significance at 0.001 level*

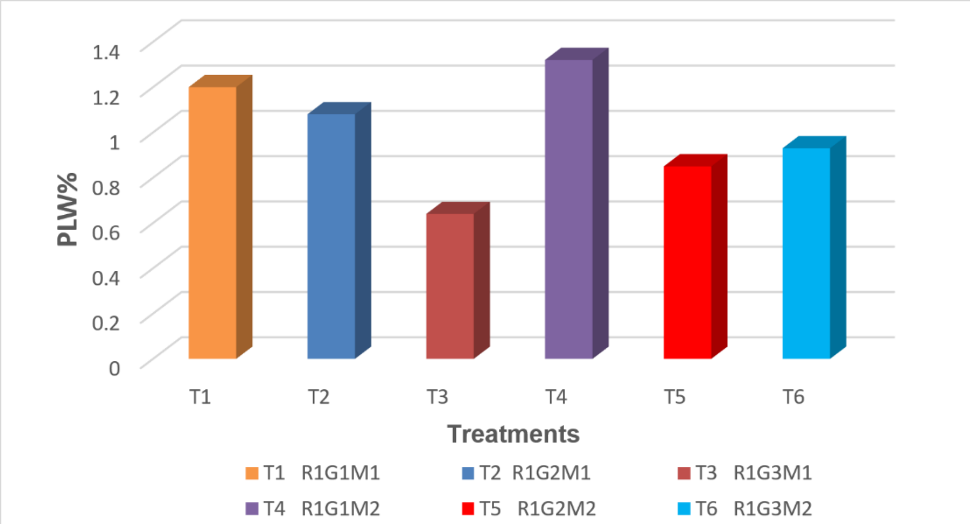

Fig. 1. Physiological loss in weight for various treatments in Palak under ambient conditions

3.2 Effect of Packaging Materials and Gas Composition on PLW (%) of Coriander Stored at Ambient Conditions

A weight loss of 1.4 % to 2.4 % occurred during storage. It was evident from Fig. 2 that Treatment T2 caused the least amount of weight reduction, followed by Treatment T6. LDPE bags exhibited the least physiological weight loss followed by PP bags. Respiration and transpiration of the produce in storage are the main causes of the weight loss [12].

3.3 Effect of Packaging Materials and Gas Composition on PLW (%) of Palak Stored at Refrigerated Conditions

Over the course of storage, weight loss varied from 0.17% to 0.74%. Fig. 3 shows that minimal loss of weight is recorded in T9 followed by T12 and LDPE bags were found better compared to PP. Mostly the weight loss was caused by respiration and transpiration [12]. T10 treatment showed the highest percentage weight loss .The produce stored in a cold atmosphere at 5°C showed a slight (%) weight loss after 14 days.

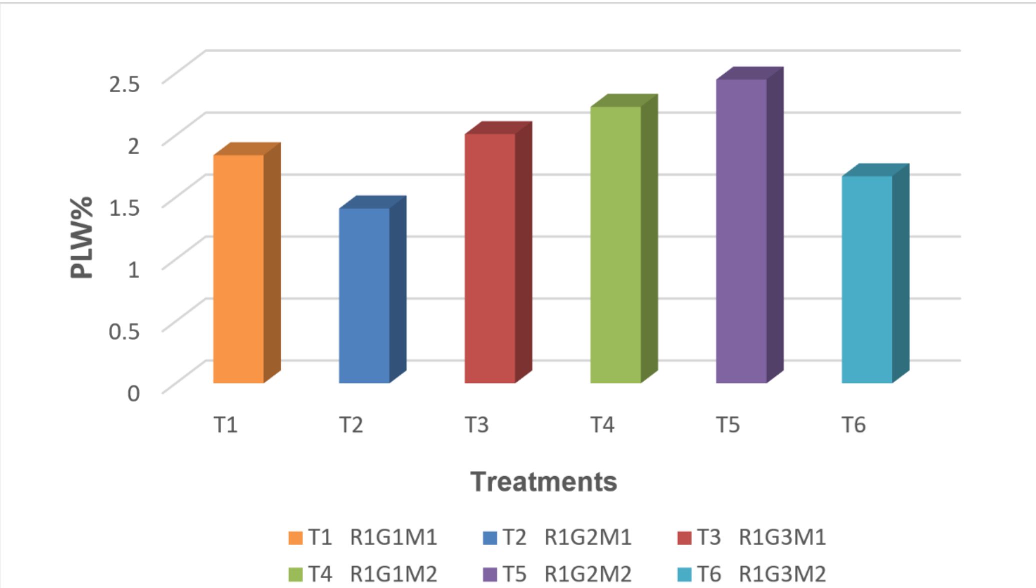

Fig. 2. Physiological loss in weight for various treatments in Coriander under ambient conditions

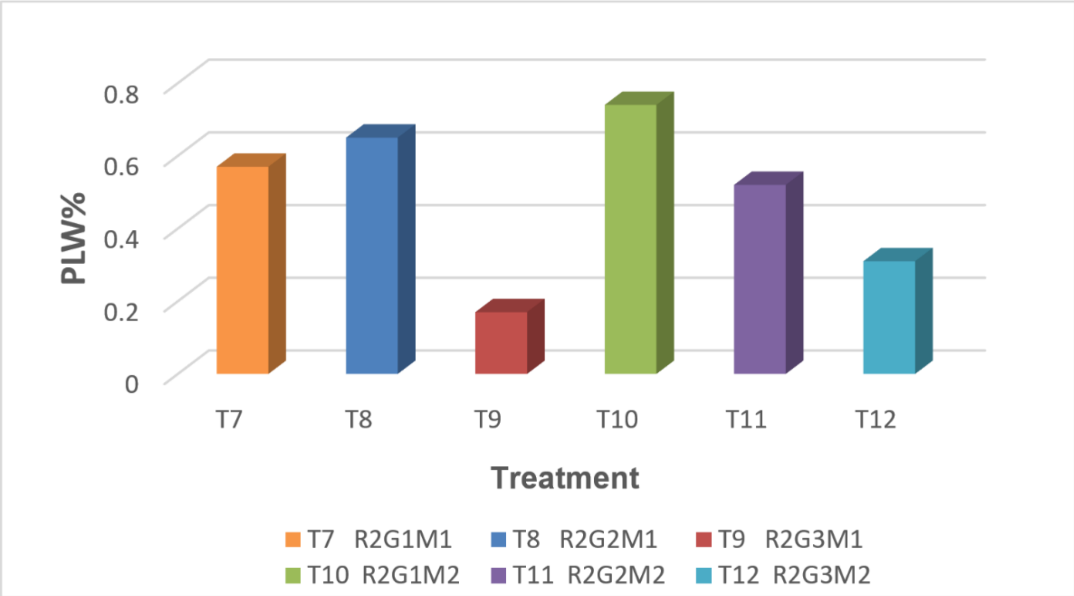

Fig. 3. Physiological loss in weight for various treatments in Palak under refrigerated conditions

3.4 Effect of Packaging Materials and Gas Composition on PLW (%) of Coriander Stored at Refrigerated Conditions

Coriander can be kept in the refrigerator for up to 12 days with little PLW, shrinkage, rotting, colour loss, and optimum freshness, earning the consumer preference [13]. Weight loss ranged from 0.3% to 1.2% over the period of storage. As per Fig, 4, T12 and T8 noticed minimal weight loss, and PP bags performed better than LDPE. The T7 treatment resulted in the highest percentage weight loss. In the case of produce packed in LDPE, leaf yellowing was also observed after 11 days.

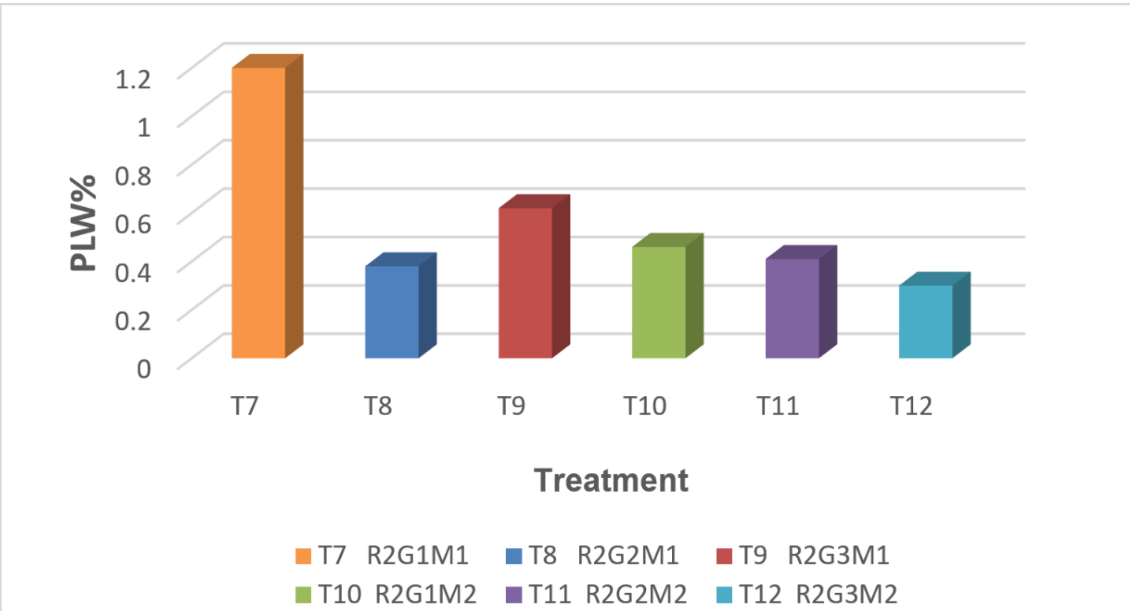

Fig. 4. Physiological loss in weight for various treatments in Coriander under refrigerated conditions

P_1 P_2

Fig. 5. Palak stored under refrigerated conditions at 16th day (P_1 – packed in LDPE material and P_2 – packed in PP material)

P_1 P_2

Fig. 6. Coriander stored under refrigerated conditions at 16th day (P_1 – packed in LDPE material and P_2 – packed in PP material)

4. CONCLUSION

Palak packed in LDPE covers had a minimal amount of physiological weight loss (%), followed by PP in both the storage environments. LDPE proved to be the ideal material for packaging. The gas composition G_3 (4% O_2, 5% CO_2) was found best among other gas compositions. The highest shelf life of Palak was found to be 3 and 14 days when kept in LDPE covers at room temperature and refrigerated storage conditions respectively.

In Coriander, under ambient conditions, the minimal PLW (%) was recorded in the produce packed in LDPE with gas composition G_2 (6% O_2, 5% CO_2) followed by the produce packed in PP covers with G_3 (4% O_2, 5% CO_2). Whereas in case of refrigerated conditions, it is PP and G_3 followed by LDPE with G_2 are found superior.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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