Effect of different packaging materials on storage life of fresh coriander (*Coriandrum sativum* L) leaves

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Abstract: Fresh culinary herbs are one of the fastest growing markets for gourmet production on a world wide scale. Some herbs are sold fresh rather than dry because they do not retain their flavor when dried. Coriander (*Coriandrumsativum* L.) plant is an important aromatic culinary herb. A study was carried out during two successive summer seasons 2010 and 2011, at the laboratory of Spices and Plantation Crops as well as that of the Post Harvest Technology of Horticultural Crops, in BCKV (Agricultural University), Mohanpur, West Bengal (India). This study aimed to investigate the effect of room and refrigerated temperatures as well as different packaging materials on the storage life of fresh coriander leaf and the changes that took place during storage till it remained to be marketable as fresh. Freshly harvested coriander leaves were packed in seven different packaging materials (brown paper packet, news paper packet, laminated paper packet, A4 poly packet, A5 poly packet, box with leaf cushioning including one control i.e. no packaging material) and were stored at room and refrigerated conditions. From visual observation, it may be concluded that coriander leaves packed in laminated paper packet and A5 poly packet remained marketable up to 10 days in storage at ambient condition. However under refrigerated condition, leaves showed high degree of marketability up to 10 DAS and medium marketability up to 12 DAS with laminated paper packet (T3), A4 poly packet (T4), A5 poly packet (T5) and box with leaf cushioning (T6) treatments.

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1. Introduction

Coriander is locally known as *dhane*, *dhania and cilantro* and botanically as *coriandrum sativum* (Ahmed, 1984). The stem, leaves and fruits of this widely acclaimed crop have a pleasant aromatic flavour and is used in preparing chutneys, sauces and soups. Medicinal potentialities of coriander are widely acclaimed (Shukla et al., 2013; Enas, 2010; Samyah, 2014). Coriander leaves are important ingredients of salads for their attractive green colour and widely acceptable aroma. They are also used to garnish many dishes before serving the meals on the dining table (Kamat et al., 2003) and form an abundant source of minerals and vitamins (Kaur et al., 2006). The leaves constitute a rich source of vitamin C (10.2 mg/1.8 g) and of vitamin D (105.3 IU) (Skip The Pie.Org, 2014).

Over the last couple of years, demand for fresh coriander herbs in India and overseas has increased rapidly with a potential for further market expansionboth at domestic as well as export. Just like many other food products which are perishable by nature, it requires protection from spoilage during their preparation, storage and distribution to give them desired shelf-life.Approximately 85% of growers and distributors have very little knowledge of handling the fresh leaves particularly during transport. Even in developed countries, when refrigerated vans are used, poor handling and temperature management practices may still occur during the marketing chain. With very little control over the temperature during distribution and lack of proper handling protocols fresh herb quality suffers and wastage is high. The principal causes of such degraded qualityand wastage are physical injuries, shriveling due to excessive moisture loss, high respiration rates, microbial infection and, in some cases, chilling injuries.It is always a challenge to keep the coriander leaf in fresh conditions for a considerable period of time in normal condition. The main spoilage mechanisms affecting the shelf life of the fresh-cut products are oxidation phenomena, due to the enzymatic activity of the cut leaves, moisture loss and proliferation of spoilage and pathogenic microorganisms (Gimenez et al., 2003).

The dehydration processes not only affects the colour and other pigments but also the sensory attributes like colour, appearance, texture, aroma and overall quality to a varying degree. Although visual quality could be maintained for up to 22 days, typical cilantro aroma decreased notably after 14 days, regardless of storage conditions (Loaiza and Cantwell, 1997). In order to select a suitable packaging material for spices, it is essential to know the factors which affect the quality of spices viz., moisture content, loss of aroma / flavour, discolouration, insect infestation, microbial contamination, etc. In order to maintain the quality of the spices during handling, transportation,

storage anddistribution, the packaging material to be used is to be selected with care, keeping in mind the functional as well as the marketing requirements. Previous research works explored the influence of low environmental impact, packaging materials on the respiration rate of minimally processed lettuce, (Del Nobile et al., 2006, 2008). Herbs can also be packaged in bags designed to minimize water loss and store refrigerated (Bhide, 2006). Results of the study of Jaggi et al., (2005) on acceptability of spinach and fenugreek stored in flexible consumer packages showed that non-perforated packets are significantly more acceptable than stored in perforated packets. It also reveals that low temperature helped to improve the shelf life of leafy vegetables upto six days.

In this agroclimatic region some researches on coriander confirmed its cultivation potential for leaf (Panda et al, 2007; Sharangi et al 2011; Guha et al, 2013) as well as superiority of non-perforated packages over perforated packages throughout the period of storage irrespective of pretreatment and types of packages (Kharkongor et al, 2010).The use of low cost packaging materials and ambient temperatures in refrigerated conditionare probably the two most important means of extending the storage life of fresh coriander leaves at household level. According to Watada and Li (1999) good quality fresh-cut product with sufficient shelf-life can be attained by recognizing and controlling factors that have a deteriorative effect on quality.As Jahan et al (2015) opined that post harvesting is mostly performed by women, this kind of easy and cheap post harvest operation with coriander leaves may be popular both in rural as well as urban population. Hence an attempt was made to test the efficiency of different packaging materials and to examine the effect of storage temperature variations on the shelf life and acceptability of coriander leaves.

2.Materials and Methods

The present study was carried out at the laboratory of Spices and Plantation Crops as well as at Post Harvest Technology of Horticultural crops in BCKV (Agricultural University), Mohanpur, West Bengal (India) during two successive seasons of 2011 and 2012. The experimental design was factorial complete randomized block design with three replicates. All the plants stored inside seven different storage materials at two temperatures (room and refrigerator) for maximum upto 12 days storage periods.

Plant samples of *Coriandrum sativum* L., (coriander) were taken from the Horticultural Research Station, Mondouri, Bidhan Chandra Krishi Viswavidyalaya. Coriander plants were harvested on the first week of December in both the years. Early in the morning and before harvesting, plants were gently washed in the field with a water hose to remove the field dust off the plants. Two hours later, plants were harvested by cutting the herb 10cm above soil surface without bruising or injuring the leaves and stems. Then they were placed in plastic crates on tissue paper for one hour to cool down, fanned and transported to the laboratory. Fresh herb samples were tied using rubber bands into 100-g bundles (to simulate local and international marketing conditions) after weighing and kept in seven different packaging materials viz., brown paper packet (P1),news paper packet (P2), laminated paper packet (P3), A4 poly packet (P4), A5 poly packet (P5),box with leaf cushioning (P6) and control (P7). The temperature (maximum and minimum in ^{0}C), rainfall (mm) and relative humidity (maximum and minimum in $^{\%}$) has been summarized in figures 1a and 1b.

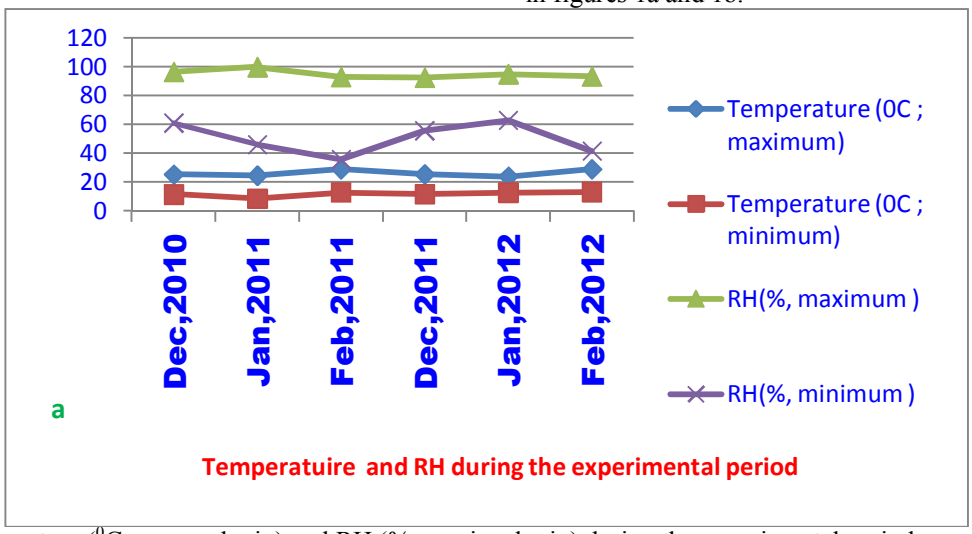

Fig 1a. Temperature (^{0}C, max and min) and RH (%, maxi and min) during the experimental period

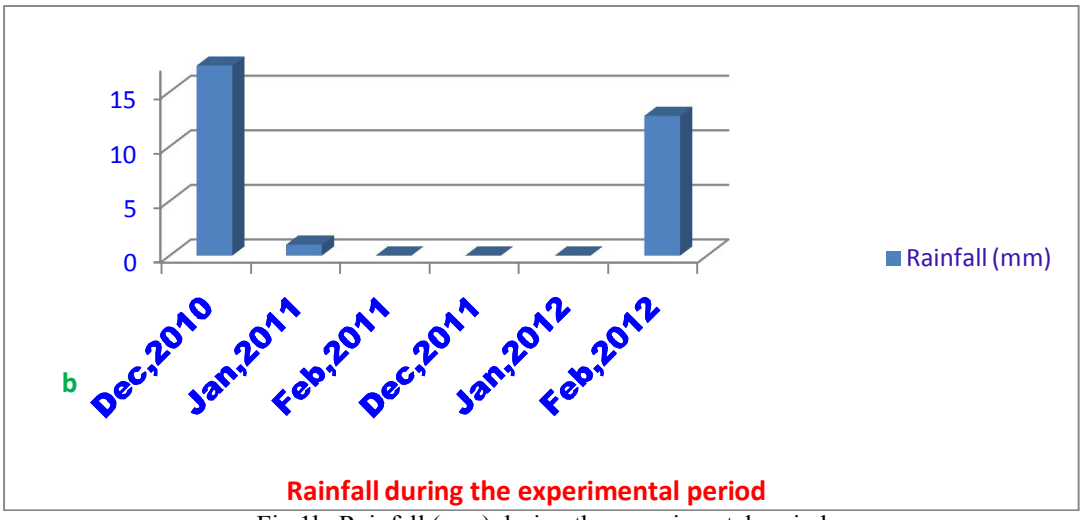

Fig 1b. Rainfall (mm) during the experimental period

At periodic intervals, packaged and unpackaged samples were removed from the storage rooms and were immediately analysed for physical and sensory changes which occurred during storage. Weight was determined by direct weighing of previously selected bundles. Bundles were inspected for freshness, shrinkage, rotting, colour, and marketability by a panel comprising six semi-trained individuals. Freshness was rated as follows: 0 = unsalable; 50 = deteriorated but salable; 75 = slightly deteriorated; and 100 = freshness as at harvest. This has been modified after that proposed by Hirata et al (1987). Shrinkageand rotting were determined as percentage of the surface area of the leaves of each bundle of coriander affected and percentage of rotten leaves Both were rated as follows: 1 = none; 2 = l-10%; 3 = l0-25%; 4 = 25-50%; and 5 = 50-100%.

For determining physiological loss in weight (PLW) of all coriander leaves, the weight of the leaves was recorded and the total loss **in** physiological weight was then calculated by subtracting the final weight of the leaves from the initial weight. The results were then expressed in percentage using following formula:

% PLW= (Initial weight-Final weight)/ Initial weight X 100

One-way analysis of variance (ANOVA) and means comparison through Duncan's multiple range tests were performed on the data to determine significant ($P < 0.05$) differences through the SPSS software (version 12.0). Percentages of freshness, shrinkage and rotting were transformed into arcsine square root values for analysis.

1-Brown paper packet**(P1). 2-**News paper packet **(P2).3-**Laminated paper packet **(P3), 4-**Perforated A4 poly packet**(P4). 5-**A5 poly packet **(P5), 6-**Box with leaf cushioning **(P6), 7-**Control **(P7)**

3. Results

3.1 Effect of different packaging materials on weight of fresh coriander leaves on storage

Table 1 clearly shows that weight loss was more in room condition compared to that of the refrigerated. Moreover there is a gradual reduction in weights with the highest value observed at 2-DAS and the lowest at12-DAS. Among all the treatments, T_5 (A5 poly packet) has been found to show the highest weight both in room as well as refrigerated condition. This is followed by T3 (Laminated paper packet) and T4 (A4 Poly packet). The lowest value in this regard was found in case of the treatment T7 (control).

From Table 1b it was evident that loss in physiological weight (PLW) increases with duration of storage. However weight loss was more in the leaves stored at ambient than in refrigerated temperature throughout the storage period. Among the different packaging materials used, minimum PLW was observed in leaves with A4 poly packet followed by laminated paper packet for packaging of coriander leaves while maximum PLW was reported in leaves without any packaging material (control) in both the temperature regime.

Table 1a: Weight[#] of fresh coriander leaves on storage as influenced by different packaging materials

Treatments	2-DAS		6- DAS		10-DAS		12-DAS	
	Room	Refri	Room	Refri	Room	Refri	Room	Refri
T1	$74.967^{d}\pm$ 0.6506	$89.5^{c}\pm$ 1.1358	$65.9^{d}\pm$ 1.0149	$81.367^{c}\pm$ 1.193	$54.067^{d}\pm$ 0.4041	$74.767^{b}\pm$ 0.6429	$41.767^{e}\pm0.6807$	$65.733^{c}\pm0.9452$
T2	$70^{e}\pm$ 0.3606	$80.933^{e}\pm$ 1.1846	$56.133^{f}\pm$ 0.5132	$75.9^{d}\pm$ 0.8544	$46.1^{e}\pm$ 0.9539	$63.567^{d}\pm$ 0.5132	$34.867^{f}\pm$ 0.8083	$53.4^{e}\pm$ 1.1533
T3	$95.7^{b}\pm$ 0.755	$99.2^{a}\pm$ 0.6245	$85.633^{b}\pm$ 0.9292	$88.167^{a}\pm$ 0.6658	$75.767^{b}\pm$ 0.2082	$74.767^{b}\pm$ 0.2082	$66.433^{b}\pm$ 0.9292	$68.733^{b}\pm$ 0.2517
T4	$93.6^{c}\pm$ 0.7937	$96.5^{b}\pm$ 0.866	$83.133^{c}\pm$ 0.2309	$86.467^{b}\pm$ 0.9866	$71.267^{c}\pm$ 1.2055	$72.867^{c}\pm$ 0.2309	$61.533^{c}\pm$ 1.0786	$60.5^{d}\pm$ 0.4359
T5	$97.767^{a}\pm$ 0.2082	$99.367^{a}\pm$ 0.3215	$89.667^{a}\pm$ 0.2887	$87.967^{a}\pm$ 0.0577	$82.433^{a}\pm$ 1.4844	$85.833^{a}\pm$ 0.1528	$71.6^{a}\pm$ 1.6523	$75.9^{a}\pm$ 0.1
T6	$71.1^{d}\pm$ 0.1732	$89.633^{c}\pm$ 0.8505	$61.833^{e}\pm$ 0.2887	$74.833^{d}\pm$ 0.1528	$53.533^{d}\pm$ 0.4726	$61.633^{e}\pm$ 1.7926	$44.1^{d}\pm$ 1.4177	$50.8^{f}\pm$ 0.5292
T7	$68.967^{g}\pm$ 0.0577	$87.5^{d}\pm$ 0.5	$53.567^{g}\pm$ 0.5132	$75.6^{d}\pm$ 0.5292	$46.233^{e}\pm$ 0.4041	$56.933^{f}\pm$ 0.4933	$34.867^{f}\pm$ 0.6351	$43.033^{g}\pm$ 0.5508

Table showing values as mean ± standard deviation (SD). [#]Initial weight at 0-DAS was 100g.
Values in a column followed by the same letter are not significantly different at $P \leq 0.05$,Duncan's multiple range test.

Table 1b: Physiological loss in weight (PLW %) of coriander leaves[§] on storage as influenced by different packaging materials

Treatments	2-DAS		6- DAS		10-DAS		12-DAS	
	Room	Refri	Room	Refri	Room	Refri	Room	Refri
T1	25.033	10.5	34.1	18.633	45.933	25.233	58.233	34.267
T2	30	19.067	43.867	24.1	53.9	36.433	65.133	46.6
T3	4.3	0.8	14.367	11.833	24.233	25.233	33.567	31.267
T4	6.4	3.5	16.867	13.533	28.733	27.133	38.467	39.5
T5	2.233	0.633	10.333	12.033	17.567	14.167	28.4	24.1
T6	28.9	10.367	38.167	25.167	46.467	38.367	55.9	49.2
T7	31.033	12.5	46.433	24.4	53.767	43.067	65.133	56.967

T1: Brown paper packet, T2: News paper packet, T3: Laminated paper packet, T4: A4 poly packet, T5: A5 poly packet, T6: Box with leaf cushioning, T7: control, Room: At room temperature, Refri: At refrigerated condition, DAS: Days after storage. [§]PLW at 0-DAS was 0.

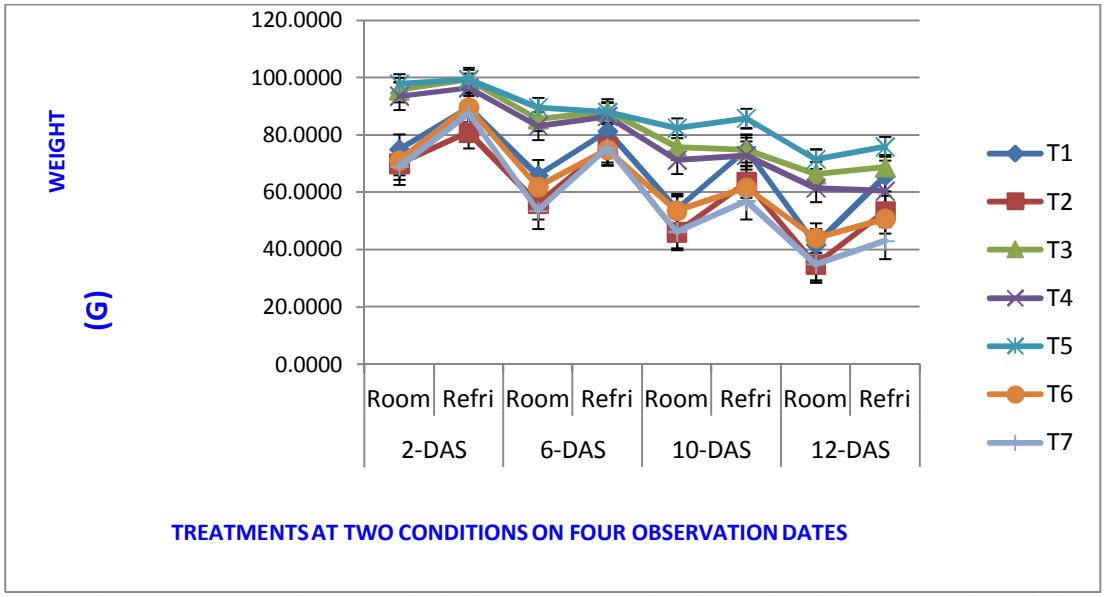

Fig 2. Effects of treatments on weight (g) of coriander leaves at room and refrigerated conditions on four dates of observation

3.2 Effect of different packaging materials on freshness (%) coriander leaves on storage

The freshness rating was done at a range between 0 (unsalable) to 100 (freshness as at harvest). From Table 2, it is evident that freshness (%) of coriander leaves is more in refrigerated condition compared to that of the room. Moreover there is a gradual reduction in freshness (%) with the highest value observed at 2-DAS and the lowest at12-DAS. Among all the treatments, T_5 (A5 poly packet) has been found to show the highest degree of freshness (%) of coriander leaves both in room as well as refrigerated

condition. This is followed by T3 (Laminated paper packet) and T4 (A4 Poly packet). The lowest value in this regard was found in case of the treatment T7 (control).

3.3 Effect of different packaging materials on shrinkage (%) coriander leaves on storage

The shrinkage rating was done at a range between 0 (unsaleable) to 100 (freshness as at harvest). Table 3 gives a clear representation of different treatments to affect the shrinkage (%) of coriander leaves both in room as well as refrigerated condition. The highest shrinkage (%) was found with control since the beginning to the end of the experiment. Storage in room condition was found to give more shrinked leaves compared to that in refrigerated conditions during respective days of observation.T_5 (A5 poly packet) has been found to show the lowest shrinkage (%) of coriander leaves both in room as well as in refrigerated condition. This is followed by T4 (A4 Poly packet) and T3 (Laminated paper packet). The highest value (45.33 %) in this regard was found in case of the treatment T7 (control).

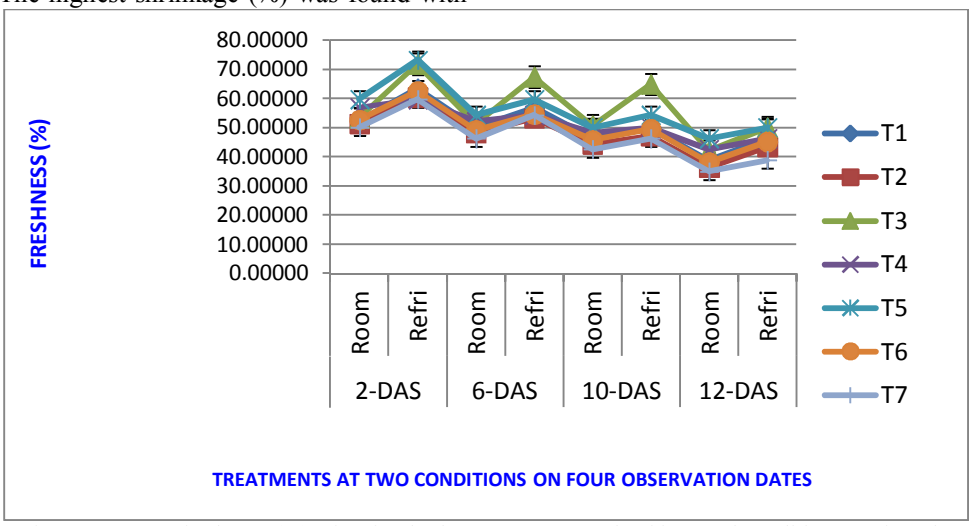

Fig 3. Effects of treatments on freshness (%) of coriander leaves at room and refrigerated conditions on four dates of observation

Table 2: Freshness (%) of coriander leaves on storage as influenced by different packaging materials

Treatments	2-DAS		6- DAS		10-DAS		12-DAS	
	Room	Refri	Room	Refri	Room	Refri	Room	Refri
T1	75.67 d ±0.774 (60.45)	93.67^{bc} ±1.7778 (75.49)	66.00^{d}± 1.21 (54.337)	83.67^{bcd}± 1.178 (66.177)	55.33^{b}± 1.7697 (48.836)	69.33^{c}± 1.4444 (56.384)	38.33^{c}± 0.8992 (38.25)	57.67^{ab}± 1.2091 (49.41)
T2	79.67^{c}± 1.083 (63.21)	96.33^{b}± 2.4656 (79.137)	70.00^{c}±0 (56.789)	84.33^{bc}± 0.4571 (66.686)	58.00^{b} ±1.1612 (49.606)	71.33^{bc}± 1.9283 (57.648)	40.00^{c} ±0 (39.23)	59.00^{ab} ±0.5825 (50.19)
T3	89.33^{a}± 1.058 (70.95)	97.33^{b} ± 1.9669 (0.734)	77.67^{a}± 1.7268 (61.821)	86.33^{b}± 1.2853 (68.324)	70.00^{a}±0 (56.789)	80.67^{a}± 1.6558 (63.94)	48.33^{b} ±0.8757 (44.05)	67.00^{a} ±1.0515 (54.94)
T4	84.00^{b} ± 1.33 (66.44)	92.33^{bc}± 6.2369 (74.688)	74.00^{b}± 1.1247 (59.351)	81.33^{d}± 0.8435 (64.409)	68.67^{a} ±1.5393 (55.356)	78.33^{a}± 0.4026 (62.26)	50.00^{b}± 1.1462 (45)	66.67^{a} ±0.9269 (54.74)
T5	90.67^{a} ±1.1576 (72.23)	99.33^{a}± 4.6939 (87.29)	80.00^{a}± 1.4341 (63.453)	90.00^{a}± 1.9196 (71.622)	70.67^{a} ±0.7291 (57.21)	80.67^{a}± 1.1037 (63.926)	60.67^{a}± 0.6783 (51.16)	70.33^{a} ±0.9605 (57.00)
T6	78.67^{c} ±0.8124 (62.50)	93.00^{bc}± 2.0259 (74.74)	69.00^{cd}± 0.6195 (56.17)	83.33^{cd} ± 1.1821 (65.92)	58.33^{b} ±0.8885 (49.799)	74.00^{b}± 0.6532 (59.345)	39.00^{c}± 0.5874 (38.65)	41.00^{b} ±0.8173 (38.19)
T7	69.33^{e} ±0.7153 (56.38)	88.33^{c}± 2.5124 (70.115)	55.33^{e}± 0.665 (48.062)	77.33^{e}± 0.7862 (61.574)	49.00^{c} ±0.6618 (44.618)	58.00^{d}± 1.1612 (49.606)	29.00^{d}± 0.6314 (32.58)	38.67^{b} ±0.8998 (38.45)

Table showing values as mean ± standard deviation (SD), Freshness rating of 0 (unsalable) to 100(freshness as at harvest).
Numbers in parenthesis denote arc-sine transformed values.
Values in a column followed by the same letter are not significantly different at $P \leq 0.05$,Duncan's multiple range test.
T1: Brown paper packet, T2: News paper packet, T3: Laminated paper packet, T4: A4 poly packet, T5: A5 poly packet,
T6: Box with leaf cushioning, T7: control, Room: At room temperature, Refri: At refrigerated condition, DAS:Days after storage

Table 3: Shrinkage (%) of coriander leaves on storage as influenced by different packaging materials.

Treatments	2-DAS		6- DAS		10-DAS		12-DAS	
	Room	Refri*	Room	Refri	Room	Refri	Room	Refri
T1	9.00^{b}± 1.0026 (17.441)	-	26.67^{a} ± 0.7452 (31.088)	10^{b}±0 (18.435)	27.00^{b}± 0.645 (31.304)	18.33^{c}± 0.426 (25.35)	48.67^{a} ± 0.6618 (44.236)	38.67^{b} ±0.6783 (38.448)
T2	13.67^{a}± 1.2853 (21.676)	-	28.67^{a}± 0.7291 (32.369)	10^{b}±0 (18.435)	29.00^{b}± 0.631 (32.581)	20.00^{c}±0 (26.565)	48.00^{a}± 1.1471 (43.853)	35.33^{b}± 1.8382 (36.459)
T3	0.013^{c}±0 (0.641)	-	8.67^{c}± 1.1576 (17.098)	0.0125^{c}±0 (0.641)	22.33^{c}± 0.3961 (28.201)	10.00^{e}±0 (18.435)	42.33^{b}± 1.209 (40.587)	29.33^{c}± 0.7291 (32.79)
T4	9.00^{b}± 1.0026 (17.441)	-	20.00^{b} ± 1.4341 (26.547)	10^{b}±0 (18.435)	17.67^{d}± 1.905 (24.819)	15.33^{d}± 0.4571 (23.05)	38.6^{c}± 0.8998 (38.447)	25.3^{d}± 2.0283 (30.192)
T5	0.013^{c} ±0 (0.641)	-	10.00^{c}±0 (18.435)	0.0125^{c}±0 (0.641)	16.67^{d}± 0.881 (24.087)	15.33^{d}± 1.2082 (23.036)	32.00^{d}± 1.228 (34.443)	19.33^{e}± 0.8435 (26.078)
T6	10.00^{b}±0 (18.435)	-	18.67^{b}± 0.8435 (25.591)	15^{a} ± 0.8027 (22.779)	23.33^{c}± 1.0315 (28.877)	22.00^{b}± 1.3845 (27.957)	35.67^{c} ± 0.3457 (36.67)	38.67^{b}± 1.3635 (38.444)
T7	14.33^{a}± 0.4698 (22.244)	-	28.00^{a} ± 1.2768 (31.939)	14^{a} ± 1.4541 (21.947)	37.00^{a}± 1.0309 (37.462)	25.00^{a}± 0.6617 (29.997)	48.67^{a}± 1.7517 (44.235)	45.33^{a}± 0.665 (42.322)

Table showing values as mean ± standard deviation (SD), Shrinkage rating of 0 to 100 per cent.
No shrinkage seen during 2-DAS at refrigerated condition; Numbers in parenthesis denote arc-sine transformed values.
Values in a column followed by the same letter are not significantly different at $P \leq 0.05$, Duncan's multiple range test.

3.4 Effect of different packaging materials on rotting (%) coriander leaves on storage

Table 4 gives an account of rotting (%) of coriander leaf observed during 2-, 6-, 10- and 12-DAS at room and refrigerated condition. Almost no rotting was found after 2-DAS. Rotting started at 3-DAS onwards, increased with time and become the maximum at 12-DAS. T_5 (A5 poly packet) has been found to show the lowest rotting (%) of coriander leaves both in room as well as in refrigerated condition. This is followed by T4 (A4 Poly packet) and T3 (Laminated paper packet). The highest value (51.00 %) in this regard was found in case of the treatment T2 (news paper packet).

3.5 Effect of different packaging materials on colour and marketability of coriander leaves on storage

Observations recorded on colour of coriander leaves under different packaging materials as well as different temperature condition were kept in Table 5. It showed that leaves kept in A5 poly packet and laminated paper packet were pale green after 10 days in storage at ambient temperature, colour of leaves under rest other treatments were unacceptable on that day. Under refrigerated condition, leaves under the same treatments were acceptable with pale green leaves after 12 days storage while leaves under other treatments were unacceptable. Leaves without any packaging were acceptable only up to 2 days in room and 6 days in refrigerated condition.

Table 4: Rotting (%) of fresh coriander leaves on storage as influenced by different packaging materials

Treatments	2-DAS		6- DAS		10-DAS		12-DAS	
	Room	Refri	Room	Refri	Room	Refri	Room	Refri
T1	No rotting	No rotting	20.33^{a} ± 1.0832 (26.793)	10.00^{a}±0 (18.435)	27.00^{b}± 0.6454 (31.304)	18.33^{b}± 0.426 (25.35)	49.33^{a} ± 0.3308 (44.618)	29.33^{c} ± 0.3627 (32.792)
T2	No rotting	No rotting	19.00^{a} ± 0.7305 (25.837)	10.00^{a}±0 (18.435)	30.00^{a} ±0 (33.211)	18.67^{b} ± 0.8435 (25.591)	51.00^{a} ± 0.5731 (45.573)	36.00^{b} ± 0.5969 (36.869)
T3	No rotting	No rotting	11.00^{c} ± 0.9165 (19.358)	0.01^{b}±0 (0.641)	21.33^{c}± 1.5986 (27.488)	10.67^{d} ± 1.0583 (19.046)	42.67^{b} ± 2.6687 (40.772)	33.67^{b} ± 1.2583 (35.46)
T4	9.67^{a} ±0.5643 (18.109)	No rotting	14.00^{b} ± 0.8261 (21.965)	10.00^{a}±0 (18.435)	24.33^{b} ± 0.3846 (29.556)	13.00^{c}± 0.8525 (21.125)	38.33^{c} ± 0.8992 (38.251)	28.00^{c} ± 1.2768 (31.939)
T5	No rotting	No rotting	9.00^{d} ± 1.0026 (17.441)	0.01^{b}±0 (0.641)	20.00^{c} ± 1.4341 (26.547)	9.33^{d} ± 1.1576 (17.767)	35.67^{c} ± 1.242 (36.665)	23.00^{d} ± 0.6809 (28.655)
T6	No rotting	No rotting	19.00^{a} ± 0.7305 (25.837)	9.33^{a}± 1.1576 (17.767)	26.33^{b}± 0.991 (30.868)	18.33^{b}± 1.5583 (25.328)	48.00^{a} ± 1.1471 (43.853)	28.67^{c} ± 0.7291 (32.369)
T7	10.33^{a} ±1.4267 (18.72)	No rotting	19.67^{a} ± 0.4175 (26.324)	9.33^{a}± 0.5643 (18.109)	30.33^{a}± 1.3034 (33.41)	23.67^{a}± 1.0336 (29.102)	50.67^{a} ± 0.6618 (45.382)	39^{a} ± 0.5874 (38.645)

Table showing values as mean ± standard deviation (SD), Rotting percentage rating of 0 to 100 per cent
No rotting seen during 2-DAS at refeigerated condition; Numbers in parenthesis denote arc-sine transformed values.
Values in a column followed by the same letter are not significantly different at $P \leq 0.05$, Duncan's multiple range test.

Table 5: Colour© of fresh coriander leaves on storage as influenced by different packaging materials

Treatments	0-DAS		2-DAS		6- DAS		10-DAS		12-DAS	
	Room	Refri	Room	Refri	Room	Refri	Room	Refri	Room	Refri
T1	1	1	2	1	3	2	4	3	5	6
T2	1	1	2	1	3	2	4	3	5	5
T3	1	1	2	1	2	2	3	2	6	3
T4	1	1	3	2	4	3	5	4	5	6
T5	1	1	1	1	2	2	3	2	6	3
T6	1	1	3	2	4	3	6	3	5	5
T7	1	1	3	2	4	3	5	3	7	5

T1: Brown paper packet, T2: News paper packet, T3: Laminated paper packet, T4: A4 poly packet, T5: A5 poly packet,
T6: Box with leaf cushioning, T7: control, Room: At room temp, Refri: At refrigerated condition, DAS: Days after storage,COLOUR:: 1:Dark Green, 2:Green, 3:Light Green, 4:Slight Fade, 5:Yellow/Fade, 6:Fade, 7: Black.

Table 6: Marketability# of fresh coriander leaves on storage as influenced by different packaging materials

Treatments	0-DAS		2-DAS		6- DAS		10-DAS		12-DAS	
	Room	Refri	Room	Refri	Room	Refri	Room	Refri	Room	Refri
T1	1	1	2	3	4	2	5	4	6	5
T2	1	1	2	3	4	2	5	4	6	5
T3	1	1	3	1	2	3	2	2	4	4
T4	1	1	3	1	2	3	4	2	5	4
T5	1	1	1	1	4	3	2	2	4	4
T6	1	1	3	2	3	2	5	2	6	4
T7	1	1	2	3	5	4	7	4	7	5

T1: Brown paper packet, T2: News paper packet, T3: Laminated paper packet, T4: A4 poly packet, T5: A5 poly packet,
T6: Box with leaf cushioning, T7: control, Room: At room temp, Refri: At refrigerated condition, DAS: Days after storage, MARKETABILITY: 1: Very High, 2: High, 3: Medium High, 4: Medium, 5: Low, 6: Very Low, 7: Nil.

From visual observation of different treatments it may be concluded that coriander leaves packed in laminated paper packet (T3) and A5 poly packet (T5) remained marketable up to 10 days in storage at ambient condition and after that leaves were completely unmarketable due to rotting and blackening. However under refrigerated condition, leaves showed high degree of marketability up to 10 DAS and medium marketability up to 12 DAS with laminated paper packet (T3), A4 poly packet (T4), A5 poly packet (T5) and box with leaf cushioning (T6) treatments. Refrigerated leaves without packaging were softened and started shrinking after 2nd day of storage onward.

4. Discussion

In terms of respiration rate, coriander leaf may be categorized as moderately high (Hardenburg et al, 1986).In order to maintain the quality of coriander leaves during handling, transportation, storage and distribution, the packaging material has an important role. Most traditional materials used earlier like paper, tinplate containers and jute bags are being replaced by plastic materials for packaging due to their properties viz., light weight, easy availability, compatibility, hygeinic nature machineability, printability, heat sealability and selective barrier properties.

In the present experiment minimum PLW was observed in leaves with A4 poly packet. Nainar et al (1997) found the similar trend with amaranthus leaves. They also reported about lower physiological weight loss in refrigerated condition than under ambient conditions which actually decreased with increasing thickness of the plastic bags(200, 300, 400 or 500 gauge) which was in line with coriander leaves.

Colour changes make the leaves inferior in terms of quality and market demand which is more frequent with ambient temperature storage and where inferior packaging materials were used. Previous findings (Sotome et al, 2001) suggested that decline of functional activities of tonoplast has led to the leakage of water from vacuole to cytosol. The water leakage from vacuole causes turgor pressure drop and successive wilting. Therefore, there is quite a possibility that not only weight loss but also water

leakage from vacuole plays an important role in the storage of leafy vegetables.

Rotting may be associated with high temperature and outbreak of microorganism. Oyebanji et al (2004) found that amaranthus leaves in boxes stored well for 3 days without the loss of marketability, however, discoloration and rotting were obvious by the sixth days of storage.At room temperature,Salmonella grew more rapidly and to a higher concentration on chopped cilantro, compared with whole-leaf cilantro (Campbell et al, 2001).

Ferante et al (2004), during the experimental period of 12 days with fresh leafy vegetables, opined that the colour changes were monitored by the variations of total chlorophyll, carotenoids and anthocyanins. The potential browning development was assessed by polyphenol measurements.

The superiority of A4 and A5 polyethylene bags might be due to the fact that they acted as barriers for loss of moisture resulting in build up of high relative humidity in the vicinity of the coriander leaves and thereby retarded the moisture loss through transpiration.

It may, therefore, be concluded that fresh coriander leaves may be stored with A4 and A5 polythene packaging in ambient as well as refrigerated situation. However, in refrigerated condition it can be stored upto 12 days with minimum PLW, shrinkage, rotting, loss of colour and maximum freshness leading to consumer preference.

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