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HDPE Packing of Curry Leaves (*Murraya koenigii)* Retains its Quality Parameters with a Long Shelf Life

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ABSTRACT: Studies on the effect of different packaging techniques to improve shelf life and quality of curry leaf (*Murraya koenigii* Sprenge) was taken up with different packaging materials *viz*., HDPE, LDPE and aluminium foil with (1% vent) and without vent at two different conditions *i.e.*, ambient condition (28±2ºC) and refrigerated condition (5±2ºC). The results revealed that HDPE packaging with 1% vent @ refrigerated condition (5±2ºC) performed well in terms of least physiological loss in weight, with maximum retention of chlorophyll content, beta-carotene content and ascorbic acid content. The colour value declined slowly in HDPE packaging with 1% vent at refrigerated condition (5±2ºC).

Keywords: *Murraya koenigii*, HDPE, LDPE, aluminium foil.

INTRODUCTION

The high demand for curry leaves both in India and abroad has elevated the trading value of this product significantly. Curry leaves are kept in one of the five vegetable clusters with the greatest export potential, according to the most recent research by the Agricultural and Processed Food Products Export Development Authority (APEDA, 2021). The main importers of curry leaf from India include the United States, European nations including the United Kingdom, France, Germany and Gulf nations like Saudi Arabia, the United Arab Emirates, and Qatar (Spices board 2018).

The major problem encountered in curry leaf is its shelf life. The main cause for quality and quantity deterioration in curry leaf are fluctuations in temperature, pest attack, respiration, transpiration and improper handling. Owing to its poor shelf life, export value of this crop got declined. Hence there arise a need to shift our focus towards pre and post-harvest management of curry leaf to enhance its shelf life without any deterioration in quality and quantity.

When it comes to keeping a product's quality intact for an extended period of time, packaging is important. Effective packaging serves as a barrier against gases, moisture, and microbes. The product's freshness and quality can be preserved till it reaches the consumer with the help of the best package. However, the primary function of a package is to protect the product from various risks that could degrade its quality while being handled, distributed, and stored (Bala, 2010). Therefore, this study is designed in such a way to evaluate the influence of various packaging material like HDPE, LDPE and aluminium foil on extending the shelf life of fresh curry leaf.

MATERIALS AND METHODS

The best performed pre-harvest chemical was sprayed and it was harvested ten days after spraying. The whole leaflets along with the stem about 30 cm in length were harvested. Harvested leaves were packed in different packaging materials *viz*., Aluminium foil, HDPE and LDPE. Treatments were fixed with 1% vent in HDPE and LDPE packaging. The packed samples were stored at both ambient temperature (28 ± 2°C) and refrigerating condition (5 ± 2°C). The experiment was laid out in Completely Randomized Design with ten treatments and three replications.

The curry leaf samples were analysed for its quality parameters at 1st, 3rd, 6th, 9th, 12th, 15th, 18th and 21st day of storage.

(i) Moisture content (%). Moisture content of dried curry leaf sample was determined following Horwitz *et al.* (1970) procedure

Moisture content (%) =

$$\left(\frac{\text{Initial weight (g)} - \text{Final weight (g)}}{\text{Initial weight (g)}}\right)\times 100$$

Table 1: Treatment details.

Treatment	Details
T_1	HDPE without vent + ambient condition (28±2°C)
T_2	HDPE without vent + refrigerated condition (5±2°C)
T_3	HDPE with 1% vent +ambient condition (28±2°C)
T_4	HDPE with 1% vent + refrigerated condition (5±2°C)
T_5	LDPE without vent + ambient condition (28±2°C)
T_6	LDPE without vent + refrigerated condition (5±2°C)
T_7	LDPE with 1% vent +ambient condition (28±2°C)
T_8	LDPE with 1% vent + refrigerated condition (5±2°C)
T_9	Aluminium foil + ambient condition (28±2°C)
T_{10}	Aluminium foil + refrigerated condition (5±2°C)

(ii) Physiological loss in weight (per cent)
Physiological loss in weight was calculated from the method suggested by Koraddi and Devendrappa (2011) using the formula
Physiological loss in weight (%) =

$$\left(\frac{\text{Initial weight (g)} - \text{Final weight (g)}}{\text{Initial weight (g)}}\right) \times 100$$

(iii) Total chlorophyll content (mg/g). Total chlorophyll content of the sample was estimated by following the procedure described by Yoshida *et al.* (1971).

$$\text{Total chlorophyll content (mg/g)} = \frac{\text{OD @ 652 nm} \times \text{V}}{34.5 \times \text{W}}$$

Where,
OD – Optical Density
V – Volume of final supernatant
W – Weight of the leaf sample

(iv) Beta-carotene content (mg/100g). Beta carotene content was estimated by following Roy (1973) method. One gram of sample was ground with 3:2 ratio of petroleum ether: acetone mixture. The supernatant was collected and made up to 50ml with petroleum ether: acetone mixture. The absorbance of the sample was measured at 450 nm in spectrophotometer using petroleum ether as a blank.
Beta-carotene content =

$$\frac{3.875 \times \text{OD value @450 nm} \times \text{V} \times 100}{\text{W}}$$

Where,
OD – Optical Density
V – Volume of final supernatant
W – Weight of the leaf sample

(v) Ascorbic acid content (mg/100g). Ascorbic acid content was estimated by Horwitz (1975) method

$$\text{Ascorbic acid content} = \frac{0.5\,\text{mg} \times V_2 \times 100\,\text{ml}}{V_1 \times 5\,\text{ml} \times \text{W}}$$

Where,
V_1-Titre value of standard
V_2-Titre value of sample
W-Weight of the sample

(vi) Colour Value. The sample colour was assessed using Royal Horticulture Society colour chart 2015 edition (United Kingdom). RHS elaborated a standard colour reference system with which appropriate colour code can be identified.

The colour of curry leaf was measured using Lovibond colorimeter (LC 100). This instrument is handheld and portable. It displays L* a* and b* values. L* value represents the whiteness, a* negative value represent green whereas positive value represent red. b* negative represent blue colour whereas positive value represent yellow colour (Kulkarni and Karadbhajne 2015). Each measurement was taken for ten times at different places in the same sample and the mean value was taken as final value.

RESULT AND DISCUSSION

A critical step in ensuring that horticultural produce is fresh and appealing to consumers is packaging. An effective extension of the shelf life of horticulture produce could be achieved by packaging. To meet out the global standards, packaging is necessary for the safe movement of goods during storage and handling (Rooney 1995). Though maximum moisture content was noticed in aluminum foil package at refrigerated condition, fungal attack was earlier in that particular package. HDPE with 1% vent at refrigerated condition was considered to be the best package in recording lowest physiological loss in weight, highest beta-carotene content, ascorbic acid content, colour value and chlorophyll content. Refrigerated condition was suitable for storing the fresh curry leaf for long time. With this view, the suitable packaging material for storing the fresh curry leaf at both ambient and refrigerated condition was discussed.

Weight loss of the curry leaf was lower in T_4 - HDPE with 1% vent + refrigerated condition (5±2°C) at 21 days of storage (44.26%) whereas highest physiological loss in weight was noticed in T_3- HDPE with 1% vent + ambient condition (28±2°C) at 9th day of storage (55.12%) which is indicated in Table 2. It is clear that weight loss is rapid at room temperature. Ambrose *et al.,* (2015) reported that curry leaf kept in polyethylene bag with perforations at refrigerated condition was found to have better shelf life with least PLW. This might have been due to the barrier property of polyethylene which prevents moisture loss from the produce. Furthermore, metabolic activities slowed down at refrigerated condition thereby mitigating respiration rate of the produce (Nasrin *et al.*, 2008).

At the end of the storage period, T_{10} - aluminium foil + refrigerated condition (5±2°C) had a significant difference in moisture content. After 21 days of storage, the percentage originally decreased from 69.90 to 44.75 (Table 3). Moisture content decreased with increased days of storage. Suganthi *et al.* (2019) reported that moringa leaf packed in aluminium foil and stored at refrigerated condition registered slow decrease in moisture content. This is due to the fact that the aluminium foil act as a good barrier for moisture transmission.

A declining trend of chlorophyll content was noticed in all samples during the storage period. The fresh curry leaf packed in T_4- HDPE with 1% vent + refrigerated condition (5±2°C) exhibited a slow decrease (1.246

mg/g - 0.629 mg/g) in the chlorophyll content from 1st to 21st day of storage (Table 4). This finding is in agreement with the work of Singh and Sagar (2010). They reported that the dehydrated coriander and drumstick leaves exhibited highest chlorophyll content when it is packed in HDPE bags. This might be due to the inhibition of chlorphyllase enzyme activity which converts chlorophyll to pheophytin. The result was in accordance with Nand and Yadav (2014). They reported that dill leaves packed in HDPE with perforations registered maximum chlorophyll content due to the water accumulation in the pore space of packaging material.

The retention of ascorbic acid content was maximum in fresh curry leaf packed in HDPE with 1% vent at refrigerated condition (5±2°C). It decreased from 3.990 mg/100g to 3.570 mg/100g at the intervals of storage period (Table 5). HDPE with vent stood with highest ascorbic acid content at the end of the storage period. Though ascorbic acid retention was highest in HDPE at refrigerated condition, the deterioration of ascorbic acid content occurs with increased storage intervals. Negi and Roy (2003) reported in amaranthus and fenugreek leaves that the ascorbic acid retention was highest in the polythene package with perforations. Ahmad and Ramli (2018) reported in curry leaf that the oxidation process of ascorbic acid might be responsible for the decrease in ascorbic acid content of curry leaves. Higher ascorbic acid content in HDPE packed curry leaves was due to the presence of higher barrier to oxygen thereby preventing ascorbic acid oxidation. In terms of storage temperature, the decrease in ascorbic acid content was greater at room temperature than at 5ºC, which could be attributed to the rapid oxidation process catalyzed by heat in the packaging materials. Therefore, HDPE with vent stored at refrigerated condition was considered to be the best packaging material in terms of ascorbic acid content.

Beta-carotene content degraded with increased storage period. Highest beta-carotene content was recorded in T_4 – HDPE with 1% vent + refrigerated condition (5±2°C). The degradation is slower from 7.986 mg/100g to 7.669 mg/100g at the end of the storage in HDPE with vent package @ refrigerated condition (Table 6). This was in accordance with the research finding of Pavani and Aduri (2018). They reported that beta carotene degradation was less in amaranthus and spinach when it was packed in HDPE. The degradation of beta-carotene over storage time was due to decrease of the antioxidant capacity (Ferrante *et al.*, 2004). Negi and Roy (2003) reported that the beta carotene degradation is slower in fenugreek and amaranthus leaves when the produce is packed and kept at cold storage condition. Koukounaras *et al.* (2008) reported in peach that lipoxygenase enzyme bleaches carotenoids during storage. Furthermore, total carotenoids might be reduced due to oxygen exposure, temperature fluctuations, and changes in the structure of carotenoids.

There was a negligible difference among the treatments in essential oil content of curry leaf. Essential oil yield was higher in T_8 - LDPE with 1% vent + refrigerated condition (5±2°C). It declines from (0.200% - 0.140%) which is indicated in Table 7. This findings was in line with Ambrose *et al.*, (2015) who reported that the essential oil stood higher in curry leaf packed in polyethylene bag which was kept at refrigerated condition. According to Ebadi *et al.*, (2017) essential oil got decreased in lemon verbena with increased storage period due to alterations in light, temperature and availability of oxygen.

The green colour of the curry leaf was retained in T_4-HDPE with 1% vent and T_8-LDPE with 1% vent treatment till the end of the storage period (15 days) at refrigerated condition. Ambrose *et al.* (2015) reported that packing of curry leaf in a polyethylene bag with perforations registered highest score in colour values at refrigerated condition (Table 8). Similar results were obtained in colour (a*) of curry leaves which varied significantly at HDPE packaging (Ahmad and Ramli 2018). Barrett *et al.* (2010) reported that the colour change during storage might be due to the degradation of green pigments. The fat-soluble chlorophylls are the major pigments responsible for colour. Additionally, both enzymatic and non-enzymatic browning reactions can produce water-soluble pigments that are brown, grey, and black in hue. Polyphenol oxidase and phenylalanine ammonia lyase are two of the enzymes that catalyze the oxidation of polyphenolic compounds and the production of precursors to phenolic substrates, respectively, in browning reactions.

Table 2: Effect of packaging on physiological loss in weight (%) of curry leaf.

Treatment	Physiological loss in weight (%)							
	Days of Storage							
	1	3	6	9	12	15	18	21
T_1	13.09	21.37	30.05	42.62	-	-	-	-
T_2	11.07	17.36	23.65	28.90	35.29	41.64	46.93	55.18
T_3	25.17	37.45	46.77	55.12	-	-	-	-
T_4	8.12	12.37	16.33	20.98	26.67	33.06	39.95	44.26
T_5	10.90	19.58	27.97	40.17	-	-	-	-
T_6	15.92	20.17	26.86	35.92	42.90	50.96	57.00	63.99
T_7	22.09	34.48	45.26	53.65	-	-	-	-
T_8	9.86	15.11	19.80	25.75	33.04	39.29	42.98	48.27
T_9	19.86	28.49	39.62	47.94	-	-	-	-
T_{10}	12.72	17.24	25.49	33.85	40.17	44.46	52.12	58.59
Mean	14.88	22.36	30.18	38.49	17.80	20.94	23.89	27.02
Sed	0.39	0.63	0.42	0.99	0.63	0.48	0.71	0.81
CD (P=5%)	0.817	1.319	0.876	2.081	1.329	1.015	1.484	1.689

Table 3: Effect of packaging on moisture content (%) of curry leaf.

Treatment	Moisture content (%)							
	Days of Storage							
	1	3	6	9	12	15	18	21
T_1	64.03	56.78	45.09	36.46	-	-	-	-
T_2	65.32	59.04	53.12	48.37	42.44	38.85	35.29	32.17
T_3	55.19	43.56	35.26	28.12	-	-	-	-
T_4	69.54	65.29	61.43	54.77	54.30	50.68	46.75	42.46
T_5	68.20	63.95	56.70	47.38	-	-	-	-
T_6	62.80	57.12	50.74	45.94	39.36	35.51	31.83	27.33
T_7	57.04	47.68	39.73	31.48	-	-	-	-
T_8	69.21	64.63	60.88	57.26	51.18	47.51	44.20	41.85
T_9	68.21	63.55	58.26	50.36	-	-	-	-
T_{10}	69.90	66.82	63.07	59.82	56.13	52.08	48.60	44.75
Mean	64.94	58.84	52.42	45.99	24.34	22.46	20.66	18.85
Sed	1.366	1.479	1.283	0.682	0.640	0.747	0.371	0.609
CD (P=5%)	2.851	3.087	2.677	1.423	1.336	1.56	0.775	1.272

Table 4: Effect of packaging on total chlorophyll content (mg/g) of curry leaf.

Treatment	Total chlorophyll content (mg/g)							
	Days of Storage							
	1	3	6	9	12	15	18	21
T_1	1.190	1.047	0.909	0.787	-	-	-	-
T_2	0.825	0.769	0.721	0.679	0.648	0.589	0.521	0.423
T_3	0.521	0.386	0.261	0.143	-	-	-	-
T_4	1.246	1.118	1.103	1.045	0.977	0.871	0.775	0.629
T_5	1.129	1.087	0.946	0.818	-	-	-	-
T_6	0.729	0.704	0.639	0.572	0.504	0.459	0.376	0.305
T_7	0.628	0.488	0.353	0.225	-	-	-	-
T_8	1.231	1.089	1.045	0.897	0.781	0.676	0.591	0.52
T_9	0.898	0.773	0.625	0.476	-	-	-	-
T_{10}	0.962	0.904	0.845	0.741	0.673	0.578	0.496	0.438
Mean	0.936	0.837	0.745	0.638	0.358	0.317	0.276	0.232
Sed	0.017	0.022	0.017	0.016	0.009	0.011	0.011	0.006
CD (P=5%)	0.034	0.046	0.035	0.032	0.017	0.023	0.022	0.011

Table 5: Effect of packaging on ascorbic acid content (mg/100g) of curry leaf.

Treatment	Ascorbic acid content (mg/100g)							
	Days of Storage							
	1	3	6	9	12	15	18	21
T_1	**3.86**	**3.83**	**3.79**	**3.70**	-	-	-	-
T_2	3.76	3.74	3.72	3.65	3.52	3.45	3.39	3.36
T_3	3.32	3.21	3.10	3.08	-	-	-	-
T_4	3.99	3.97	3.96	3.85	3.77	3.71	3.64	3.57
T_5	3.82	3.67	3.58	3.47	-	-	-	-
T_6	3.65	3.52	3.48	3.42	3.37	3.29	3.22	3.18
T_7	3.52	3.35	3.25	3.16	-	-	-	-
T_8	3.9	3.85	3.80	3.74	3.64	3.58	3.50	3.47
T_9	3.62	3.49	3.42	3.41	-	-	-	-
T_{10}	3.76	3.74	3.73	3.68	3.60	3.52	3.46	3.42
Mean	3.72	3.64	3.58	3.52	1.79	1.75	1.72	1.70
Sed	0.052	0.071	0.067	0.084	0.041	0.042	0.065	0.029
CD (P=5%)	0.107	0.147	0.140	0.175	0.084	0.088	0.135	0.06

Table 6: Effect of packaging on beta-carotene content (mg/100g) of curry leaf.

Treatment	Beta-carotene content (mg/100g)							
	Days of Storage							
	1	3	6	9	12	15	18	21
T_1	7.652	7.599	7.531	7.455	-	-	-	-
T_2	7.126	7.070	7.034	7.000	6.964	6.942	6.917	6.898
T_3	6.982	6.523	6.495	6.938	-	-	-	-
T_4	7.986	7.947	7.918	7.882	7.832	7.800	7.765	7.669
T_5	7.820	7.784	7.719	7.690	-	-	-	-
T_6	7.227	7.202	7.164	7.078	7.039	7.000	6.931	6.862
T_7	6.990	6.858	6.529	6.940	-	-	-	-
T_8	7.890	7.868	7.817	7.778	7.658	7.622	7.586	7.544
T_9	7.245	7.200	7.161	7.093	-	-	-	-
T_{10}	7.652	7.599	7.531	7.455	7.147	7.108	7.039	6.954
Mean	7.42	7.33	7.26	7.30	3.66	3.64	3.62	3.59
Sed	0.097	0.14	0.159	0.154	0.103	0.137	0.105	0.13
CD (P=5%)	0.202	0.292	0.332	0.322	0.214	0.284	0.219	0.271

Table 7: Effect of packaging on essential oil (%) of curry leaf.

Treatment	Essential oil (%)			
	Days of Storage			
	1	9	14	21
T_1	0.150	0.147	-	-
T_2	0.145	0.120	0.118	0.112
T_3	0.133	0.130	-	-
T_4	0.170	0.164	0.132	0.125
T_5	0.155	0.143	-	-
T_6	0.138	0.125	0.125	0.120
T_7	0.140	0.135	-	-
T_8	0.200	0.180	0.150	0.140
T_9	0.142	0.130	-	-
T_{10}	0.148	0.142	0.130	0.120
Mean	0.15	0.14	0.06	0.06
Sed	0.003	0.003	0.002	0.002
CD (P=5%)	0.005	0.005	0.004	0.004

Table 8: Effect of packaging on colour value of curry leaf.

Treatment	Colour Value															
	Day 1		Day 3		Day 6		Day 9		Day 12		Day 15		Day 18		Day 21	
	Colour Code	Colour	Colour Code	Colour	Colour Code	Colour	Colour Code	Colour	Colour Code	Colour	Colour Code	Colour	Colour Code	Colour	Colour Code	Colour
T_1	N134C	Strong Green	N134C	Strong Green	N134D	Brilliant Green	NN137A	Greyish Olive Green	-	-	-	-	-	-	-	-
T_2	N134C	Strong Green	N134D	Brilliant Green	135A	Dark Green	135A	Dark Green	135A	Dark Green	135B	Moderate Green	137C	Moderate Yellow Green	NN137C	Greyish Olive Green
T_3	N134C	Strong Green	N134D	Brilliant Green	NN137A	Greyish Olive Green	137C	Moderate Yellow Green	-	-	-	-	-	-	-	-
T_4	N134C	Strong Green	N134C	Strong Green	N134C	Strong Green	135A	Dark Green	135A	Dark Green	135A	Dark Green	135B	Moderate Green	137C	Moderate Yellow Green
T_5	N134C	Strong Green	N134C	Strong Green	NN137A	Greyish Olive Green	137C	Moderate Yellow Green	-	-	-	-	-	-	-	-
T_6	N134C	Strong Green	N134D	Brilliant Green	N134D	Brilliant Green	135A	Dark Green	135B	Moderate Green	137C	Moderate Yellow Green	NN137C	Greyish Olive Green	NN137C	Greyish Olive Green
T_7	N134C	Strong Green	N134D	Brilliant Green	135B	Moderate Green	NN137A	Greyish Olive Green	-	-	-	-	-	-	-	-
T_8	N134C	Strong Green	N134C	Strong Green	N134D	Brilliant Green	N134D	Brilliant Green	135A	Dark Green	135A	Dark Green	135B	Moderate Green	135B	Moderate Green
T_9	N134C	Strong Green	N134D	Brilliant Green	135B	Moderate Green	NN137A	Greyish Olive Green	-	-	-	-	-	-	-	-
T_{10}	N134C	Strong Green	N134D	Brilliant Green	N134D	Brilliant Green	135A	Dark Green	135A	Dark Green	135B	Moderate Green	135B	Moderate Green	NN137C	Greyish Olive Green

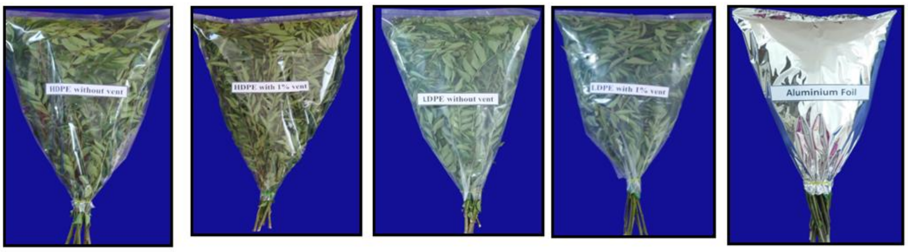

Fig. 1. Packaging of fresh curry leaf.

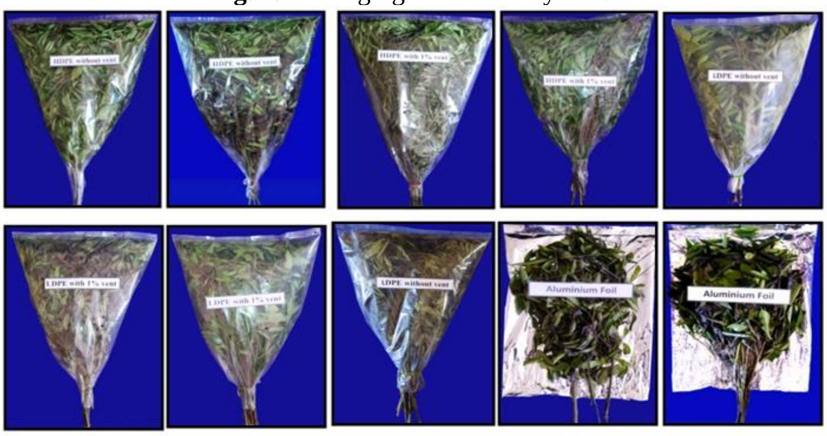

Fig. 2. Packaging of fresh curry leaf under ambient and refrigerated condition at the end of storage period.

CONCLUSIONS

The present investigation revealed that HDPE packaging of curry leaf with 1% vent @ refrigerated condition (5±2ºC) performed well in terms of least physiological loss in weight, maximum retention of chlorophyll content, beta-carotene content and ascorbic acid content. The colour value declined slowly in HDPE packaging with 1% vent at refrigerated condition (5±2ºC). This finding can be recommended for commercial packaging of curry leaf.

FUTURE SCOPE

Identified technology of HDPE packaging of curry leaf with 1% vent @ refrigerated condition (5±2ºC) could be tested for commercial packing and retention of colour of curry leaf.

Conflict of Interest. None.

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