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Standardization of suitable packaging material to increase shelf life and quality parameters of curry leaf (*Murraya koenigii* Sprenge)

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Abstract
Curry leaf, also known as *Murraya koenigii* Sprenge, is a member of the Rutaceae family and is an aromatic spice. In South India, leaves are primarily used for culinary purpose. An investigation was conducted to find the best packing material for the leaves of curry leaf in order to extend their shelf life and maintain their high-quality standards. In the present experiment, ply cardboard boxes with ventilation, sleeves of various gauges, jute cloth bags and polypropylene bags were used as treatments. Compressed packing in polypropylene bags performed well than other packaging materials in terms of least physiological weight loss, more shelf life, high chlorophyll, ascorbic acid and essential oil content and less percentage of senescence.

Keywords: Curry leaf, shelf life, packaging materials, physiological and quality traits

Introduction
Curry leaf is scientifically known as *Murraya koenigii* belonging to the family Rutaceae with a basic chromosome number of 2n = 18, cultivated commercially for its aromatic leaves which are majorly consumed in South India for culinary purpose. It is cultivated on a commercial scale in large areas in Tamil Nadu, Andhra Pradesh and Karnataka. The leaves have 66.3% moisture, 6.1% protein, 16% carbohydrates, 6.4% fibre, 600 mg phosphorus, 0.93 mg iron and 7.56 mg β- carotene per 100 g (Shankaracharya and Natrajan, 1971) [7]. The essential oil of curry leaf is widely used in flavouring dishes and has high cosmetic value. It owns anti-microbial, anti-diabetic, anti-oxidant and anti-cancer property. It cures dysentery, asthma, vomiting, piles and influenza. As curry leaf is rich in iron, it is also been utilized in curing anaemia. The antioxidant and anti-carcinogenic effect of curry leaf have been studied and it has been reported curry leaf as a potential reducer of the toxicity of carcinogens (Khanum *et al*., 2001) [4].
Among the horticultural products, leafy vegetables are one that leads to spoilage rapidly. There will be a change in developmental, structural, physiological and biochemical process leading to senescence of the leaves. The most obvious symptoms of senescence in the leaves are loss of fresh weight, shrivelling, flavour changes *etc.*, (Halvey and Mayak, 1981) [3]. One of the most common leafy spices in the world is curry leaf. In addition to being consumed domestically, the leaves have good export potential (Lathan Kumar *et al*., 2003) [5]. The leaves are available all year long. Leaves of curry leaf are prone to wilt and lose moisture quickly. They cannot be kept fresh for longer than a day because they are extremely perishable. Due to increased global demand, fresh curry leaves will have a better export market if their shelf life is extended. Also prepacking of fresh leaves helps in easy transportation and handling of the produce. Hence the present study is undertaken to identify the suitable packaging material to increase shelf life and quality parameters of curry leaf.

Material and Methods
The experiment was carried out at Department of Spices and Plantation crops and the experiment was laid out in completely randomized block design (CRD) with seven treatments and four replications. Different packaging material was fixed and the treatments were imposed as per the technical programme. The leaves were harvested during the early morning hours. Fresh curry leaves were washed and air-dried to remove the surface abnormalities like yellowing, pest damage was eliminated. These samples were packed in different packaging materials to study the shelf life and to observe the quality parameters such as physiological

loss in weight (%), shelf life (days), moisture content, relative water content (%), total chlorophyll content (mg/100g), ascorbic acid content (mg/100gm), essential oil content (%), colour value and percentage of senescence.

The treatment details followed in the experiment were as follows;

T_1: Control- 3 ply cardboard box with ventilation
T_2: T_1 + Packing in sleeves of 100 gauge
T_3: T_1 + Packing in sleeves of 50 gauge
T_4: T_1 + Packing in sleeves of 100 gauge + basal cotton
T_5: T_1 + Packing in sleeves of 50 gauge + basal cotton
T_6: Compressed Packing in jute cloth bag
T_7: Compressed Packing in polypropylene bags

Results and Discussion

Curry leaf kept under different packaging material were studied for the different parameters showed significant results. For physiological loss in weight, the treatment T_7-compressed packing in polypropylene bags was found to be the best with minimum physiological loss in weight of 13.55%, 16.20%, 20.20% and 25.96% at 2, 4, 6 and 8 days, respectively compared to T_1-control @ 3 ply cardboard box with ventilation (60% and 85.2% at 2 and 4 days, respectively). This might have been due to the barrier property of polyethylene which prevents moisture loss from the produce (Nasirin *et al.*, 2008) [6]. Treatments T_2, T_4, T_6 and T_7 observed to have maximum number of shelf life i.e., 8 days followed by treatment T_3 and T_5 (6 days), whereas treatment T_1 showed minimum number of shelf life i.e., 4 days.

Treatment T_7- Compressed Packing in polypropylene bags was found to be best with highest moisture content of 66.95%, 64.32%, 62.08% and 61.00% at 2, 4, 6 and 8 days, respectively when compared to T_1-Control @ 3 ply cardboard box with ventilation (57.09% and 38.30% at 2 and 4 days, respectively). Treatment T_7- Compressed Packing in polypropylene bags was recorded the maximum relative water content of 93.72%, 89.03%, 85.55% and 82.32% at 2, 4, 6 and 8 days, respectively when compared to T_1-Control @ 3 ply cardboard box with ventilation (77.71% and 30.22% at 2 and 4 days, respectively). Among the different packing treatment T_7- Compressed Packing in polypropylene bags with 3% ventilation recorded highest chlorophyll content of 6.895, 6.765, 6.652 and 6.590 mg/100g at 2, 4, 6 and 8 days, respectively when compared to T_1-Control @ 3 ply cardboard box with ventilation (6.541 and 6.425 at 2 and 4 days, respectively). The T_7- Compressed Packing in polypropylene bags was recorded highest ascorbic acid content 0.785, 0.770, 0.752 and 0.736 mg/100g at 2, 4, 6 and 8 days, respectively when compare to T_1-Control @ 3 ply cardboard box with ventilation (0.545 and 0.521 at 2 and 4 days, respectively). From the study, highest essential oil content of 0.04%, 0.04%, 0.03% and 0.03% at 2, 4, 6 and 8 days, respectively was noticed in Treatment T_7 when compared to T_1-control @ 3 ply cardboard box with ventilation (0.02%). similar results were reported by Dawn *et al*., 2015 [2].

Color of leaves noted from Royal Horticulture Society ranged from strong, brilliant and dark green to moderate olive green. The T_7-compressed packing in polypropylene bags was exhibited bright green, light green with yellowing or browning and light green with noticeable yellowing or browning at 2, 4, 6 and 8 days, respectively when compared to T_1-Control @ 3 ply cardboard box with ventilation (Light green with more yellowing or browning at 4 days). Barrett *et al.*, (2010) reported that the color change during storage might be due to the degradation of green pigments. Less percentage of senescence was observed in the treatment T_7-compressed @ packing in polypropylene bags (No senescence, 20%, 25% and 32% at 2, 4, 6, 8 days respectively) compared to T_1-control @ 3 ply cardboard box with ventilation (No senescence and 80% at 2 and 4 days, respectively).

Table 1: Effect of different packaging materials on physiological parameters of curry leaf

Treatment		Physiological loss in weight (%)				Moisture content (%)				Relative water content (%)				Percentage of senescence (%)			
		2nd day	4th day	6th day	8th day	2nd day	4th day	6th day	8th day	2nd day	4th day	6th day	8th day	2nd day	4th day	6th day	8th day
T_1	Control- 3 ply cardboard box with ventilation	60	85.2	-	-	57.09	38.30	-	-	77.71	65.20	-	-	No	80	-	-
T_2	T_1 + Packing in sleeves of 100 gauge	14.28	20.17	28.00	36.6	59.19	58.00	50.00	47.25	79.59	70.44	62.05	58.47	No	20	29	40
T_3	T_1 + Packing in sleeves of 50 gauge	39.29	48.20	57.20	-	54.30	53.05	47.25	-	76.34	72.46	67.44	-	No	25	45	-
T_4	T_1 + Packing in sleeves of 100 gauge + basal cotton	20.05	26.50	30.80	35.05	62.02	60.50	58.22	55.00	83.06	80.04	78.25	75.00	No	20	30	38
T_5	T_1 + Packing in sleeves of 50 gauge + basal cotton	38.25	42.05	46.05	-	66.92	59.60	54.20	-	73.22	70.69	65.07	-	No	24	32	-
T_6	Compressed Packing in jute cloth	15.68	20.08	24.55	26.82	63.57	62.00	61.08	60.00	89.61	85.10	81.50	78.66	No	25	38	36
T_7	Compressed Packing in polypropylene bags	13.55	16.20	20.20	25.96	66.95	64.32	62.08	61.00	93.72	89.03	85.55	82.32	No	20	25	32
S.E.M.		0.68	0.51	0.49	0.40	1.05	0.97	0.62	1.05	1.44	0.60	0.98	0.63	-	-	-	-
C.D.		2.10	1.56	1.51	1.24	3.23	2.97	1.91	3.23	4.43	1.84	3.01	1.95	-	-	-	-

Table 2: Effect of different packaging material on quality traits of curry leaf

Treatment		Total chlorophyll content (mg/100 g)				Ascorbic acid (mg/100 g)				Essential oil content (%)				Colour			
		2nd day	4th day	6th day	8th day	2nd day	4th day	6th day	8th day	2nd day	4th day	6th day	8th day	2nd day	4th day	6th day	8th day
T_1	Control- 3 ply cardboard box with ventilation	6.541	6.425	-	-	0.545	0.521	-	-	0.02	0.02	-	-	4	1	-	-
T_2	T_1 + Packing in sleeves of 100 gauge	6.891	6.750	6.650	6.488	0.485	0.480	0.476	0.452	0.02	0.02	0.01	0.01	4	3	2	1
T_3	T_1 + Packing in sleeves of 50 gauge	7.021	6.965	6.852	-	0.636	0.622	0.615	-	0.03	0.03	0.03	-	4	2	1	-
T_4	T_1 + Packing in sleeves of 100 gauge + basal cotton	6.705	6.625	6.532	6.425	0.699	0.685	0.672	0.658	0.07	0.05	0.05	0.04	4	3	2	1
T_5	T_1 + Packing in sleeves of 50 gauge + basal cotton	6.658	6.593	6.258	-	0.558	0.525	0.516	-	0.01	0.01	0.01	-	4	2	2	-
T_6	Compressed Packing in jute cloth	6.785	6.658	6.620	6.583	0.799	0.785	0.734	0.712	0.04	0.04	0.03	0.03	4	3	2	2
T_7	Compressed Packing in polypropylene bags	6.895	6.765	6.652	6.590	0.785	0.770	0.752	0.736	0.05	0.04	0.04	0.04	4	3	3	2
S.E.M.		0.084	0.114	0.099	0.059	0.022	0.013	0.008	0.007	1.44	0.60	0.98	0.63	-	-	-	-
C.D.		0.256	NS	0.302	0.181	0.067	0.039	0.026	0.022	4.43	1.84	3.01	1.95	-	-	-	-

Conclusion

The study indicated that compressed packing of curry leaf in polypropylene bags was the best method for extending its shelf life and maintaining its quality criteria, followed by T6-compressed packing in jute cloth and T_1-control @ 3 ply cardboard box with ventilation. Therefore, by prolonging the fresh curry leaf's shelf life by using polypropylene bags, we can expand its export market as a result of rising global demand.

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