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M Suganthi
PG Scholar, Department of Horticulture Agricultural College and Research Institute, Madurai, Tamil Nadu, India

TN Balamohan
Professor and Head, Department of Horticulture Agricultural College and Research Institute, Madurai, Tamil Nadu, India

A Beaulah
Associate Professor, Department of Horticulture Agricultural College and Research Institute, Madurai, Tamil Nadu, India

S Vellaikumar
Department of biotechnology, Agricultural College and Research Institute, Madurai, Tamil Nadu, India

Correspondence
TN Balamohan
Professor and Head, Department of Horticulture Agricultural College and Research Institute, Madurai, Tamil Nadu, India

Extending the shelf life of Moringa leaves through packaging and cold storage

M Suganthi, TN Balamohan, A Beaulah and S Vellaikumar

Abstract
Green leafy vegetables are highly nutritious and occupies a predominant role in Indian diet. A variety of greens are consumed in different parts of a country among which moringa leaves stands top. Leafy vegetables are perishable in nature and so their shelf life depends on the storage conditions. In the view of increasing the demand for green leafy vegetables with fresh good quality, a research has been undertaken to assess the quality of moringa leaves by using different packaging materials and different storage conditions. Influence of packaging conditions on moringa leaves were studied during two different storage temperatures. The pretreated moringa leaves were packaged in Low Density Polyethylene (LDPE) of 150 gauge thickness, High Density Polyethylene (HDPE) of 400 gauge thickness with and without one percentage vent and aluminum foil kept under both ambient air temperature and refrigerated conditions. The results revealed that quality deterioration was found to be lower in aluminum foil followed by HDPE without vent kept at refrigerated conditions respectively. Aluminum foil wrapped treatment was found to be best in retaining the colour, less reduction in vitamin C content, protein content and higher moisture content with the higher shelf life of twelve days.

Keywords: Packaging, storage, shelf life, moringa leaves

Introduction
Moringa oleifera Lam. is native to India had been acclimatized to many regions of tropics and sub-tropics around the world. It is also called as Horse Raddish tree, Drumstick tree, Magic tree, Marango, Saijihan and Sajna (Fahay, 2005) [9]. It is regarded as most useful tree since every part of it is used as food or medicine or for industrial purpose (Kallafalla *et al*., 2010) [15]. Moringa is said to provide seven times more vitamin C than oranges, ten times more vitamin A than carrots, seventeen times more calcium than milk, nine times more protein than yoghurt, fifteen times more potassium than bananas and twenty five times more iron than spinach (Rockwood *et al*., 2013) [13]. Nutrients present in moringa are essential for vision, blood, bones and skin. Deficiency of such nutrients leads to anaemia, xerophthalmia and night blindness and scurvy. Since moringa leaves are rich in antioxidants it is used to boost our immune system (Sauveur *et al*., 2017) [20]. India, Pakistan, Phillipines, Hawaai and some African nations make use of leaves, flowers, fruits, pods of moringa for edible purpose (Anwar *et al*., 2006) [7]. Ethiopian species of *Moringa oleifera* leaves contain high concentration of energy, nutrients, minerals which reveals its therapeutic use (Amabye *et al*., 2016) [5]. Moringa leaves also contains non-nutritive chemicalsor phytochemicals involving self-defense mechanism. Those phytochemicals include catechol, tannins, steroids, triterpenoids, flavonoids, saponins, alkaloids and reducing sugars having medicinal properties.
Fresh leaves contain nutrients in higher quantities and it is important to extend its shelf life (Sahay *et al*., 2017) [19]. Prolonging in its fresh form through pre-packaging is important in extending the shelf life making it available to ready to use form (Ambrose *et al*., 2017) [4]. To increase the shelf life and quality of leaves many cost effective and safe agro chemicals are recommended in desired quantities.
Salicylic acid (SA) is an endogenous growth regulator which regulates various physiological activities of plants such as seed germination, growth, flower induction, nutrient uptake and transport, ethylene biosynthesis, stomatal moments and photosynthesis thus helps in increasing the productivity without any deviation in quality (Hay *et al*., 2010) [11]. Foliar application of 20 mM salicylic acid on lettuce resulted in increased productivity and quality parameters than untreated control (Youseef *et al*., 2017). Brine solution plays a major role in retaining colour, texture and reduced browning properties because of its osmosis process and hence resulted in

enhanced shelf life of lettuce (Alenyorege *et al*., 2015) [3]. Shelf life of moringa leaves can be increased by adopting different packaging materials and various storage conditions (Arunkumar *et al*., 2013) [8]. Consumers show inclination towards fresh green vegetables available in edible form. There arose accelerated demand for high quality produce with retention of its original form. Hence the concept of minimal processing emerged in order to reduce the deterioration of fresh produces. In the view of extending the shelf life and to make fresh produce availability with higher nutrient rich moringa leaves, an experiment has been conducted to study the effect of different packaging materials that extends the shelf life of moringa leaves.

Methodology

Foliar spray of salicylic acid (0.01%) was giving in the experimental field and fresh leaves of PKM-1 moringa were harvested and taken to the lab. Uniformly matured moringa leaves from 4th to 7th node were harvested in morning hours. Samples of 100 g each were taken and dipped in 2% brine solution for 5 minutes followed by dipping in benzyl adenine (BA) 10ppm. After dipping treatments all the samples were completely air dried for 10 minutes and then taken for packing. Packing materials as given in the table.1.were kept at two different conditions *viz*., ambient condition 28+2ºC and refrigerated temperature 5+2ºC.

Table 1: Experimental treatments for packing and storage of moringa leaves

Treatment name	Packing material
$T_1(G_1S_1)$	HDPE without vent + Ambient condition.
$T_2(G_1S_2)$	HDPE without vent + Refrigerated at 5+2°C
$T_3(G_2S_1)$	HDPE with 1% vent + Ambient condition.
$T_4(G_2S_2)$	HDPE with 1% vent + Refrigerated at 5+2°C
$T_5(G_3S_1)$	LDPE without vent+ Ambient condition.
$T_6(G_3S_2)$	LDPE without vent + Refrigerated at 5+2°C
$T_7(G_4S_1)$	LDPE with 1%vent + Ambient condition.
$T_8(G_4S_2)$	LDPE with 1%vent + Refrigerated at 5+2°C
$T_9(G_5S_1)$	Packing in aluminum foil + Ambient condition.
$T_{10}(G_5S_2)$	Packing in aluminum foil + Refrigerated at 5+2°C

The parameters observed were Shelf life (No. of days), Moisture content (%), Protein content (mg/100g) and Vitamin- C content (mg/100g).

Ascorbic acid content (vitamin- C)

Ascorbic acid content was calculated by the procedure described by Ranganna (2001) [12].

Protein content

Protein content was calculated by the procedure described by Lowry.

Statistical analysis

Statistical analysis was carried out to study the effect of various parameters on all dependent variables. Analysis of variance (ANOVA) was conducted by using Completely randomized design (CRD) using the AGRES software.

Results and Discussion

The present study has been taken up with the objectives of minimal processing of moringa leaves packed in different thickness of both high density polyethylene (HDPE), low density polyethylene (LDPE) bags and aluminum foil kept under ambient and refrigerated conditions. The physico-chemical properties and quality parameters such as vitamin-C and protein content were analyzed in this chapter.

Table 2: Effect of packing and storage on quality content of moringa leaves

Treatments	Shelf life (days)	Moisture Content (%)	Vitamin C (mg/100g)	Protein (mg/100g)
T_1	4.00	77.86	13.2	38.12
T_2	9.00	78.57	14.0	39.50
T_3	3.00	74.64	13.6	38.87
T_4	8.00	75.36	14.0	39.58
T_5	3.00	75.77	12.8	30.52
T_6	8.00	78.07	13.2	30.85
T_7	2.00	73.40	12.8	22.65
T_8	7.00	74.61	12.4	23.03
T_9	4.00	77.08	13.2	37.8
T_{10}	12.00	79.12	14.4	47.39
Mean	5.9973	76.448	13.3597	34.7993
S.Ed	0.1251	1.6083	0.2693	0.8592
CD (0.05)	0.2610	3.3548	0.5618	1.7923

Shelf life

Juvenile produce such as leafy vegetables, lettuce and okra are harvested when they are at actively growing period that may contain 85 percent or more of moisture which may help in reducing water loss (Kays, 1991) [14]. Hence appropriate storage reduces moisture loss, slows down the respiration rate and inhibits the microbial development. The shelf life of the fresh moringa leaves after harvest was recorded. There was a gradual decrease in the shelf life with the increase in the storage period. From the Table.2.it can be seen that the rate of decrease in shelf life was minimum in moringa leaves packed and stored in refrigerated temperature, treatments than the treatments kept at ambient condition. Comparing the effect of packing materials used aluminum foil wrapped treatments kept at refrigerated temperature had an extended shelf life of twelve days than control that only had four days. Comparing the thickness of packing material polyethylene covers of 400 gauge thickness without vent kept at refrigerated temperature (T_2) was found to have shelf life of nine days followed by T_4(HDPE with vent kept at refrigerated condition)which is on par with T_6 (LDPE without vent kept at refrigerated condition)that had an enhanced shelf life of eight days. The treatment T_7 (LDPE with vent kept at ambient condition) was found to have very low shelf life of two days. These results were in accordance with Panta and Kanal (2018) [17] in which they reported that coriander leaves stored under cold conditions without perforations were found to be the best.

Moisture content

Moisture content is one of the important factors related to freshness and shelf life of fruits and vegetables. The initial moisture content of fresh moringa leaves was found to be 86 percent. From table.2.it is evident that moisture content decreased significantly with increased storage period. The losses in moisture content of moringa leaves are in agreement with the findings of Gupta and Mukherjee (1982) [10] and Adetuyi (2008) [1]. The rate of decrease in moisture content was slower in T_{10} (wrapped in aluminum foil and stored at refrigerated temperature) and T_2 (HDPE without vent kept at refrigerated condition) followed by T_6 (LDPE without vent kept at refrigerated condition) and T_9 (wrapped in aluminum foil and stored at ambient conditions. The highest moisture content of 79.12 percent was observed in T_{10} followed by78.57 percent recorded in T_2. The lowest value of 73.40 percent was recorded in T_7 (LDPE with vent kept at ambient

condition) followed by 74.61 percent in T_8 (LDPE with vent kept at refrigerated condition). Since the contact of surface area of vent with the leaves is higher in treatments T_2, T_4, T_6 and T_8, the moisture loss is observed to be more.

Ascorbic acid

Vitamin- C contributes to the antioxidant properties of the vegetables by protecting the membrane erythrocyte which maintains blood vessels thus helps in improving blood circulation (Oboh, 2005) [16]. The initial ascorbic acid content of fresh moringa leaves was found to be 16 mg/100g. From Table.2.it is observed that vitamin C content decreased with increased storage period. It was found in watermelon that vitamin-C content decreased with increased days of storage period (Albuquerque *et al*., 2005) [2]. The rate of decrease in vitamin-C was less in moringa leaves packed in treatments T_{10}, T_2 and T_4followed by the treatments T_1, T_6 and T_9 which were found to be on par with each other. The faster rate of decrease was recorded in T_8 that had ascorbic acid content of 12.4 g/100g and the slower rate of decrease was found in $T_{10}$with the value of 14.4g/100g respectively. The reason for decrease in ascorbic acid content is due to the activity of enzyme ascorbate oxidase which converts the vitamin C content to Dehydroascorbic acid in stored produce. This findings were in accordance with the study on the effect of packing materials on drumstick leaves by Arunkumar and Nirmala (2013) [8] and Adetuyi *et al*., 2008 [1].

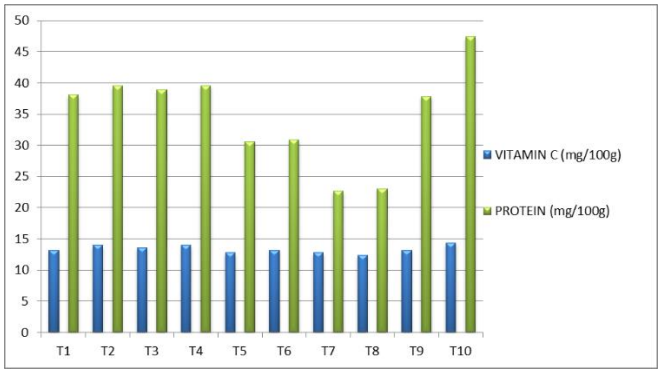

Fig 1: Effect of packing and storage on vitamin- C content and protein content of moringa leaves

Protein content

The initial protein content of fresh moringa leaves was found to be 56.23 mg/100g. From Table.2.it is observed that there is a gradual decrease in protein content along with the storage period. The decrease in protein content may be attributed to physiological and metabolic activities of the cells of moringa leaves and at the same time it is also due to proteolysis. The treatment $T_{10}$was found to have slower decrease in protein content (47.39mg/100g) at the end of the shelf life. The treatments T_1, T_2, T_3, T_4 andT_9 were found to have protein content of 38.12, 39.50, 38.87, 39.58 and 37.8 mg/100g respectively. The treatments T_7 andT_8 were observed to contain lower protein content of 22.65 and 23.03 respectively. Pavani and Priyanka (2018) [18] also reported that there is a decrease in protein content during packing and storage of dehydrated green leafy vegetables.

Conclusion

Foliar sprayed moringa leaves with salicylic acid 0.01 percent and pre-treated with 2 percent brine solution followed by benzyl adenine 10ppm solutions and air dried and packaged in aluminum foil has extends the shelf life up to twelve days at refrigerated storage condition than all other treatments. Moisture, vitamin- C content and protein content retention were observed to be high in the best treatments T_{10}. Among the ten different packing and storage treatments aluminum foil and HDPE covers without vent stored at refrigerated temperature were found to express good barrier property for microbes thus minimizing the quality loss compared to other materials. This study suggest tha the moringa leaves can be stored for maximum of twelve days without quality changes.

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