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Post Harvest Stability in *Amaranthus dubius*- A Comparative Study

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Abstract
Leafy vegetables are a rich source of vitamins, Minerals and antioxidants, their consumption among resource-poor populations in developing countries will help to mitigate these deficiencies. Post-harvest losses of leafy vegetables are estimated to be over 30% and are generally caused by poor handling and storage conditions. But, post harvest preservation of the quality of these vegetables is necessary for poor populations in developing countries. It is in this direction the present study is taken up. In the current research, leaves of Amaranthus dubius was used to determine the changes in morphological, physiological and biochemical properties of the vegetable under modified storage at low temperature. The vegetables were kept in active bags and stored in low temperatures at 18^{0}C and relative humidity of 75%. The leaf samples were taken at 1-day interval for measuring morphological and biochemical parameters like chlorophyll, carotenoid and carbohydrate content. On an average the chlorophyll content showed 35 % decrease after 5 days and 12% decrease on 3rd day, Carotenoid, a precursor of vitamins showed 44 % decrease after 5 days and 15% decrease after 3 days. The carbohydrate content showed 42% decrease after 5 days and 15% decrease after 3 days. The loss in carotenoid is highest when compared to other parameters. Based on this study, it is suggested that the use of active bag combined with low temperature storage for three days will extend the shelf life and preserve optimum amount of nutrients in Amaranthus dubius.
Key words: *Amaranthus dubius, Carbohydrates, Chlorophyll, Carotenoids, Plant Weight*

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I. INTRODUCTION

The Amaranthus genus regarded as super crops, contributing to balanced diet has a global presence in tropical and subtropical regions like India, China, United states etc. It is a hardy, drought tolerating plant, which is integrated into the traditional cuisines across Asia, Africa and America. In the current research, *Amaranthus dubius*(Red variety) a commonly grown leafy vegetable both commercially and in Urban household is taken up for the study. In recent days *Amaranthus dubius*, is cultivated on a large scale for its economic viability, nutritional benefits and adaptability to various agricultural conditions. Leaves are harvested for fresh consumption, salads and cooked dishes due to their high nutritional value. A. dubius contains high quality proteins, carbohydrates, antioxidants and dietary fibre which can be used to prevent cancer, diabetes and arteriosclerosis [10]. The vegetables are also rich sources of vitamins like A,C, K, folate and minerals like potassium ,phosphorous, calcium and magnesium [1,16]

Amaranthus has a very short shelf life after harvesting, which put constraint on production, marketing and consumption, which forces farmers to sell soon after harvest [13]. In the present study, the morphological, physiological and biochemical assessment of Amaranthus dubius is done during post harvest storage to know about nutritious quality of the vegetable.

II. Material and Methods:

Plant samples of red variety of *Amaranthus dubius* were collected from the sampling area in the early morning to minimize environmental stress. The collected plants were kept inside the iceless cooler and analyzed over three trials lasting five days each. For each trial samples were freshly collected. The samples were taken at 1-day interval for assessing morphological and biochemical parameters.

Morphological Parameters:

These include shoot length, root length, plant weight and leaf area, which were measured by taking ten randomly selected plants each day for five days in all three trials. These analysis indicates the growth, stress, nutritional content and photosynthetic capacity of the plants.

Collected plants were thoroughly washed to remove soil debris. For fresh weight, plants were blotted with a soft paper towel to remove any free surface moisture and weighed right away using electronic weighing machine. Dry weight was measured by drying the plants overnight in a low-heat oven (100° F). Shoot and Root length were measured using method of Gomez and Gomez[6]. For Leaf area, leaves were collected from different parts of the plants and measured using Grid Counting Method [14].

Biochemical Parameters:

For sample preparation 1 gm deveined leaves were taken after separating from the stem,washed and pat dried. Biochemical parameters like carbohydrates, chlorophylla, chlorophyllb, total chlorophyll and total carotenoid content were evaluated.

For analyzing the chlorophyll a, chlorophyll b, total chlorophyll and total carotenoid content Arnon's method was followed. Carbohydrates were analysed using Anthrone method [4]. The physiological parameter like relative water content was evaluated according to the method given by [11].

Result and Discussion:

The assessment of morphological and biochemical parameters provide insight into growth, physiology, stress response and overall health of the plant, which is critical for enhancing nutrition and shelf life. This also promotes sustainable agricultural practice and industrial applications by understanding the ecological interactions.

The analysis of different morphological and biochemical parameters of the red variety of *Amaranthus dubius* was conducted for 5 consecutive days in three trials, the results revealed depletion in nutrients with increase in time duration.

In the first trial, plantweight(Fig. 1) was 20.42g on the first day, this decreased to 20.29 g, 19.19 g, 19.05 g and 18.92 g on the subsequent days. Plant weight can be correlated with other morphological traits such as leaf area, stem diameter, and root length to get a comprehensive understanding of the plant's growth pattern.(Poorter and Nagel, 2000). The root length was 11.22 cm on the first day, this decreased to 11.17 cm, 11.11 cm, 10.81 cm and 10.09 cm on the subsequent days. The shoot length was 21.07 cm on the first day, this decreased to 19.67 cm, 19.66 cm, 18.51 cm and17.45cm on the subsequent days. The leaf area showed similar behavior with highest 1921.9 mm² was noticed on the first day and decreased subsequently with lowest on last day (Table 1). The decrease in leaf area indicates water stress in the plants due to change in temperature and humidity condition [17].

In the second trial, the plant weight was 20.74g on the first day, which decreased to18.94 g on the last day. Similar pattern was observed in root length with highest on the first day and decreased subsequently. The shoot length was 20.73 cm on the first day, this decreased to 19.7cm, 18.74 cm and 18.01 cm on the subsequent days. Decrease in shoot length can signal stress conditions such as nutrient deficiency or environmental change [7]. The leaf area was 1928.4 mm² on the first day, this decreased to 1382.6 mm² on the Fifth Day (Table 1).

In the third trial:The plantweight was 20.54g on the first day and 18.85 g on the last day. The root length showed similar pattern with highest on the first day and lowest on 5th day. Temperature is the another important factor which cause decreased root length with increase in number of days [5]. The shoot length was 20.54 cm on the first day, this decreased subsequently showing 18.12 cm on the last day. The leaf area was 1943.7 mm² on the first day, this decreased to 1854.1 mm², 1647.3 mm², 1465.2mm² and 1343.4 mm² on the subsequent days (Table1).

The decrease in the measure of morphological parameters such as plant weight, root and shoot length and leaf area of stored Red *Amaranthus dubius* is primarily due to lack of photosynthesis due to absence of light leading to nutrient depletion, water loss and senescence.

Biochemical Parameters: Biochemically, the red variety contains anthocyanins, which have antioxidant and anti-cancer properties. The study analyzed the red variety over five days in three trials, showing nutrient depletion over time due to factors like lack of light and water loss during storage.

In trial one, amount of Chlorophyll a was 8.73 µg/ml on the first day, it decreased to7.05µg/ml, 6.93 µg/ml, 6.65 µg/ml and 6.58 µg/ml on the subsequent days. Chlorophyll b was 19.78µg/ml on the first day, it decreased to 15.31 µg/ml on the 5th day. The total chlorophyll showed similar pattern of decrease from first to last day. Total carotenoids was 10.86 µg/ml on the first day, which decreased to 10.57 µg/ml, 9.88 µg/ml, 9.44 µg/ml and 7.50

µg/ml on the subsequent days. The decrease in the amount of plant pigments such as chlorophyll a, b and carotenoids in stored *Amaranthus dubius* occurs due to enzymatic breakdown, oxidation, pH changes and temperature variation. The amount of carbohydrates was 640µg/ml on the first day, this decreased to 340 µg/ml on the fifth day(Table 2).

In trial two, similar observation was noticed with regard to chlorophyll a as in trial one. Amount of Chlorophyll b and total chlorophyll was highest on the first day which decreased in subsequent days. The total carotenoids was highest initially, but showed almost 67% decrease on the fifth day. The carbohydrates decreased by 58 % from first day to last day.

In trial three, Chlorophyll a was 8.71µg/ml on the first day, decreased to 6.21µg/ml on the fifth day. Amount of Chlorophyll b was 23.08µg/m on the first day, decreased to 17.09µg/ml, 13.98µg/ml, 15.13µg/ml and 14.3 µg/ml on the subsequent days. Amount of total chlorophyll showed similar pattern of decrease from 31.77 µg/ml to 20.56 µg/ml. Amount of total carotenoidswas9.20 µg/ml on the first day, which decreased to 3.77µg/ml on the fifth day (table 3) .

Total chlorophyll showed 33% decrease in the first trial, 57 % in second trial and 35 % decrease in the third trial. Total carotenoid showed 31%, 34% and 60 % decrease respectively in first, second and third trial (Fig 2). Carbohydrates showed 47.1%, 32 % and 47 % decrease (Table 3). The decrease in the amount of carbohydrates in stored *Amaranthus dubius* is primarily due to several metabolic factors, such as respiration, senescence, lack of photosynthesis and enzyme activity.

Combining all the three trials, the total chlorophyll content showed 35 % decrease after 5 days and 12% decrease on 3rd day. Similar observation was made by Gross[20] in his studies on Amaranthus dubius. Lichtenthaler [9] analysed the role of chlorophyll in photosynthetic efficiency of Amaranthus dubius. Carotenoid, a precursor of vitamins showed 44 % decrease after 5 days and 15% decrease after 3 days. Manuel [14] and Nyaura et al [15] observed similar loss in vitamin c during storage of Amaranth in their studies. The carbohydrate content showed 42% decrease after 5 days and 15% decrease after 3 days. The loss in carotenoid is highest when compared to other parameters. Maeda and Salunkhe [11], Belitz [3] have also reported heavy loss of vitamin C and beta-carotene during storage of leafy vegetables.

III. CONCLUSION

The red variety of Amaranthus dubius is highly nutritional and has more amount of carotenoid along with chlorophyll, which makes it a very good source of Vitamin A. It has greater shelf life, more drought tolerant and higher relative water content making it more preferrable in the diet. Cultivating Amaranth in urban households not only promotes sustainable food practices but also provides a fresh, nutritious addition to daily meals while enhancing the aesthetic appeal of urban spaces (Singh and Kumar, 2020 and Wilson and Taylor 2021).

The decrease in the measure of morphological parameters such as plant weight, root and shoot length and leaf area of stored Red *Amaranthus dubius* is primarily due to lack of photosynthesis due to absence of light leading to nutrient depletion, water loss and senescence.

The decrease in the amount of chlorophyll, carotenoids and carbohydrates in stored *Amaranthus dubius* can be primarily attributed to several metabolic factors like respiration, senescence, lack of photosynthesis and enzyme activity, pH changes and temperature variation.

In the current research it is observed that post harvest stability of A.dubius can be achieved by storing them in refrigerators or iceless coolers up to five days, but their nutrient efficiency is the best within the first three days. This contributes to a more sustainable, nutritious, and convenient diet. These factors help to address the malnutrition concern in a cheap and effective way in a developing country like India.

Table 1.

S.No	Root length (cm)			Shoot length (cm)			Leaf Area(mm ^{2})		
	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
Day 1	11.23	11.3	11.28	21.07	20.73	20.54	1921.9	1928.4	1943.7
Day 2	11.11	11.21	11.11	19.67	19.7	19.87	1860.3	1820.7	1854.1
Day 3	10.92	10.98	10.80	19.66	19.06	19.55	1477.1	1661.9	1647.3
Day 4	10.82	10.61	10.28	18.51	18.74	19.07	1449.1	1467.1	1465.2
Day 5	10.61	10.21	10.11	17.45	18.01	18.12	1227.4	1382.6	1343.4

Table 2

S.No	Chl a (µg/ml,)			Chl b (µg/ml,)			T. Chl (µg/ml,)		
	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3	Trial 1	Trial 2	Trial 3
Day 1	8.73	9.82	8.71	21.07	20.73	20.54	1921.9	1928.4	1943.7
Day 2	7.05	9.59	7.71	19.67	19.7	19.87	1860.3	1820.7	1854.1
Day 3	6.93	9.45	7.83	19.66	19.06	19.55	1477.1	1661.9	1647.3
Day 4	6.65	5.25	6.48	18.51	18.74	19.07	1449.1	1467.1	1465.2
Day 5	6.58	4.83	6.21	17.45	18.01	18.12	1227.4	1382.6	1343.4

Table 3

Days	Amount of Carbohydrates (µg/ml,)		
	Trial 1	Trial 2	Trial 3
1	640	620	600
2	580	560	560
3	480	440	500
4	400	400	460
5	340	360	380

Fig. 1

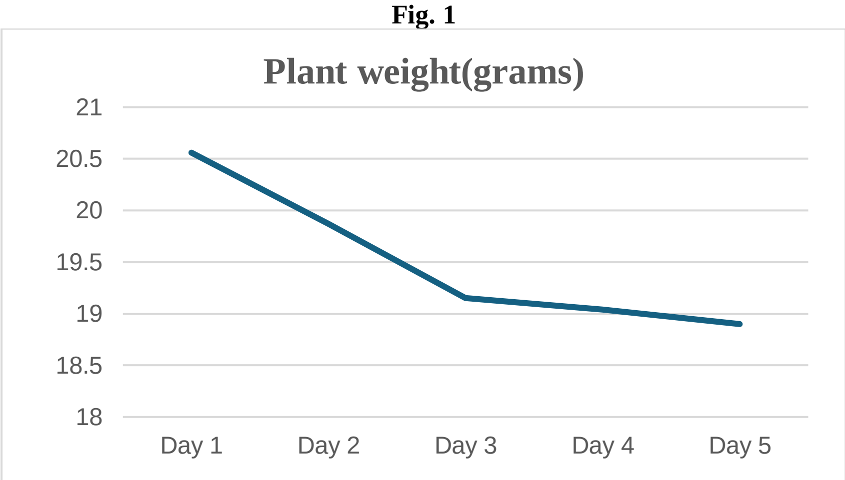
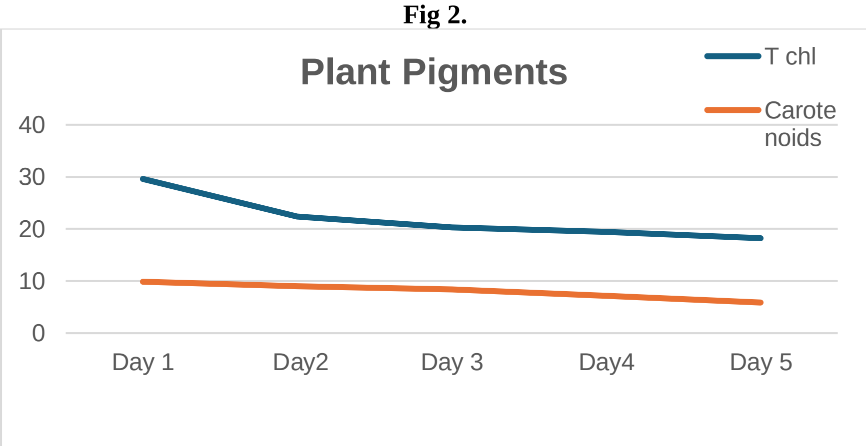


Fig 2.



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