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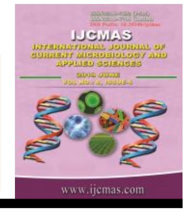

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Studies on Storage Behavior of Primary Processed Leafy Vegetables under Different Storage Conditions

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A B S T R A C T

The present investigation was undertaken in the Post – harvest Technology Laboratory of Horticulture Section, RCSM College of Agriculture, Kolhapur during 2017-18 to study effect of storage conditions on shelf life and quality of primary processed leafy vegetables. The treatment combination comprised of three storage conditions such as room temperature (RT), zero energy cool chamber (ZECC) and refrigerated storage (RS) and five different leafy vegetables such as fenugreek, coriander, spinach, pokala and rajgira in FCRD with three replications. The freshly harvested samples of leafy vegetable were packed in polyethylene bags of 200 gauge with 2 % vents and stored at different storage conditions as stated earlier. The observations on physico-chemical composition, sensorial evaluation and microbial count were recorded at regular intervals up to end of storage life of primary processed leafy vegetables. Further it was also noticed that, the increasing trend with respect to physiological loss in weight, yellowing, decay, shriveling and microbial count of primary processed leafy vegetables was noticed but the rate of increase was faster under ambient temperature as compared to zero energy cool chamber and refrigerated storage while the decreasing trend with respect to moisture, total minerals, ascorbic acid, total chlorophyll contents and sensorial qualities, but the rate of decrease was slow under refrigerated storage conditions as compared to zero energy cool chamber and room temperature. It was also found, that the moisture and mineral contents of primary processed leafy vegetables were ranged from 90% (V_5S_3) to 80.04% (V_1S_1) and 25.23% (V_1S_3) to 12.23% (V_5S_1), respectively at the end of storage life. The highest ascorbic acid retention was noticed in V_1S_3 (88.86%) whereas the lowest was noticed in V_3S_1 (21.03%) at the end of storage life. The total chlorophyll content was found to be ranged in between 30.67 mg/100g (V_2S_1) and 82.82 mg/100g (V_4S_3) at the end of storage life of primary processed leafy vegetables. The shelf life of primary processed fenugreek, coriander, spinach, pokala and rajgira could be extended to 2, 3 and 8 days, 2, 3 and 6 days, 2, 4 and 8 days, 2, 4 and 6 days and 2, 4 and 8 days at room temperature, zero energy cool chamber and refrigerated storage, respectively on the basis of physiological loss in weight, sensorial qualities and microbial count.

Introduction

India is the second largest producer of vegetables in the world and accounts for about 15 percent of the world's vegetable production. India's flora comprises of 6000 species of plants and used for consumption, one third of which are green leafy vegetables. Green Leafy Vegetables (GLV) having much importance from the nutritional point of view (Narang *et al*., 2016). The majority of people in India are economically poor and thus food choices for balanced diet are further restricted by poverty and insufficient supply of nutritious food. Green leafy vegetables are particularly rich in carotenoids (vitamin A) as well as protein, calcium, vitamin C, riboflavin, iron, magnesium, phosphorus , potassium, fiber and vitamins like folic acid, K, E and other mineral (Gibson, 1994) and being rich in these nutrients, green leafy vegetables help to combat micro-nutrient deficiencies (Borah *et al.*, 2008).The high concentration in certain bioactive phyto-chemical normally present in vegetables is the reason for their recommendations, being the high intake of vegetables correlated to lower incidence of chronic diseases (Devdas *et al*., 1980 and Prakash and Pal,1991) .

The fruits and vegetables continue to respire, transpire and ripen even after harvesting; therefore, they suffer losses in their quality and quantity between harvest and consumption. However, these losses can be avoided to some extent and the shelf –life can be extended by using appropriate production practices such as pre- cooling, packaging, storage and transportation. The post – harvest practices, refrigerated storage and packaging of vegetables can contribute in an integrated manner to reduce the losses. Because of the changes in consumer lifestyles, there is an increased demand of fresh-cut primarily processed food items, which are nutritious, functional, safe, attractive, and ready-to-eat. Minimally processed vegetables become a convenient answer to those who want to include more fresh vegetables in the daily diet (Kaur and Kapoor, 2000).

The different leafy vegetables such as fenugreek (*Trigonella foenum- graceum* L.), coriander (*Coriandrum sativum* L.), spinach (*Spinacia oleracea* L.), pokala (*Amarathus blitum)* and rajgira (*Amarathus paniculatus* L.) contain higher amount of vitamins, minerals and other nutritional components which helps in maintain the proper health. Fenugreek plays an important role in medicines as fenugreek having vital role in promoting lactation, reduces menstrual discomfort and minimizes symptoms of menopause while coriander is helpful in reducing skin inflammation and cholesterol, regulates blood pressure and preventing ulcers (Gopalan *et al*., 1982).

The minimal processing plays an important role in reducing the problems of garbage disposal in the metropolitan cities (Gomez *et al*., 2003). Work done in minimal processing of different green leafy vegetables showed that, shelf life of spinach can be extended from 3 days to 14 days by using LDPE bags at cold storage (Kakade *et al.*, 2015). Reddy *et al.* (2013) in rajgira who recorded the shelf life of 6 days under refrigerated storage while Kulkarni (2015) recorded the shelf life of 10 days for fenugreek in refrigerated storage with better retention of physico-chemical properties.

Hence, there is great scope for enhancing the shelf life of different green leafy vegetables along with better retention of their nutritive value and provide ready - to - cook leafy vegetables in consumer hands and hence the vegetables such as fenugreek, coriander, spinach, pokala and rajgira were selected for studying their storage behavior under different storage conditions. Keeping all these points in mind, the present research work was carried out to study the effect of storage conditions on shelf life and quality of primary processed leafy vegetables.

Materials and Methods

The healthy, fresh and photo-synthetically active leaves of optimal maturity of leafy vegetables viz. fenugreek, coriander, spinach, pokala and rajgira were collected from Instructional – cum- Research farm of Horticulture Section, RCSM College of Agriculture, Kolhapur and from local market of Kolhapur also. The bay as well as working and drying area of laboratory and all other instruments and equipment were sanitized with 100 ppm chlorine solution and air dried. The selected vegetables were sorted for integrity, color and size uniformity and lack of defects. Only photosynthetic leaves (green leaves) with tender stem were included in the samples. Selected leaves along with tender stem parts of leafy vegetables were washed in running tap water for 4 minutes at room temperature (20°C) in a ratio of one part of sorted leafy vegetable for 10 parts of water. The excess water was drained by using sterilized stainless steel sieves. The prepared vegetables were spread on tables and air dried. Consumer polyethylene food grade plastic bags of 25x20 cm size having 200 gauge with 2% vent were used for packaging. Processed vegetables weighing 100 g were filled in each polyethylene bags and bags were sealed by using hand operated pouch sealing machine. The well packed primary processed vegetables were stored at three different storage conditions i.e. room temperature (RT), zero energy cool chamber (ZECC) and refrigerated storage (RS, 5±1°C).

Physico-chemical analysis of primary processed leafy vegetables

Approximately 5 to 10 leaves of vegetable selected for primary processing were taken and their outer boarder was drawn on graph paper. Total area covered with leaf was measured and recorded in cm^2.The percent moisture was determined by drying known weight of sample into hot air oven at 60°C for 24 hours up to a constant known weight (A.O.A.C., 2010). The Total mineral content was estimated in terms of per cent and the total chlorophyll content were estimated as per the standard procedure given by Ranganna (2005) in terms of mg /100g. Ascorbic acid was estimated as per the modified titration procedure of A.O.A.C (2010) and measured in terms of ascorbic acid content in terms of mg per 100g of leaves.

Sensorial evaluation

Overall acceptability score for primary processed leafy vegetables was determined on the basis of colour, appearance, texture, aroma parameters of samples by a panel of evaluators based on rating with 9-point Hedonic scale given by Amerine *et al. (*1965). Overall rating was calculated and a score of 5.50 and above was considered as acceptable. Samples which recorded the score less than 5.50 were terminated.

Total microbial count (cf/g)

Total microbial count was calculated as per the standard procedure given by the Ranganna (2005) at initial and at termination of the treatment.

Statistical analysis

The data was reported as an average value of replicates with standard deviation. Analysis of variance (ANOVA) was performed using IBM SPSS Statistics 22 (Windows 8.1, Statistical analysis). The level of significance for all the tests was α=0.05 (Panse and Sukhatme, 1985).

Results and Discussion

Analysis of selected vegetables before primary processing

The data depicted in Table 1 revealed that among all the vegetables, highest weight of inedible portion was observed in coriander (655.80 g) followed by pokala (609.59 g) and fenugreek (600.25 g) at the same time spinach showed the least weight of inedible portion (351.50 g) followed by rajgira (408.50 g). It was also noticed that, the highest edible portion was noticed in spinach (648.50 g) followed by rajgira (591.50 g). The remaining vegetable viz. fenugreek, and pokala had weight of edible portion was 399.75 g and 390.41 g, respectively. The least weight of edible portion was found in coriander (344.20 g) as it had very small leaf area and its leaves are mostly taken as edible portion. As spinach with short tender leaves are considered edible for consumption as well as leaves of spinach having large leaf surface area and hence spinach recorded highest per cent edible portion (64.80) followed by rajgira (59.15) while other vegetables viz. fenugreek, coriander and pokala recorded comparatively less percentage of edible portion such as 39.97, 34.40 and 39.04, respectively as these vegetables had comparatively smaller leaf area than spinach and rajgira. The results of present findings are in accordance with the findings of Gomez *et al*., (2003) who recorded 45-50 % inedible portion in fenugreek

Physico-chemical Composition of Primary Processed Leafy Vegetables

Physical constituents / traits

Physiological loss in weight (%)

The data presented in Table 2 clearly indicated that, the physiological loss in weight of primary processed leafy vegetables was found to be increased with advancement of storage period. On 2nd day of storage, V_1 recorded highest physiological loss in weight (7.54 %) while least PLW was recorded by V_5 (5.03 %). The vegetable V_2 recorded highest PLW (9.73 %) and least PLW was noticed in V_5 (7.33 %) at the end of 6th day of storage. On 8th day of storage, highest PLW was observed in V_1 (11.21 %) and lowest PLW was recorded by V_5 (8.25 %).

Individual effect of different storage conditions on physiological loss in weight of different primary processed leafy vegetables was found to be significant and presented in Table 2. The data revealed that on 2nd day of storage, S_1 recorded highest PLW (10.85 %) and lowest PLW was recorded by S_3 (3.12 %). At the end of 6th day of storage, S_3 recorded physiological loss in weight of 8.54 % and on 8th day it was (9.64 %). The physiological loss in weight was found to be increased gradually throughout the storage irrespective of storage conditions. Rayaguru *et al.* (2010) reported that PLW at RT and ZECC was more might be due to fluctuation in outside temperature which adversely affected the relative humidity and increases PLW. The results of present findings are in accordance with the findings of Ambuko *et al.* (2017) who stated that the rate of PLW was affected by temperature and relative humidity which affects the VPD (Vapour Pressure Difference) between products and its environment and it can be controlled by reducing temperature and increasing relative humidity which might be reason for longest shelf life of vegetables at S_3i.e. refrigerated storage.

The interaction effect of different treatment combinations of vegetable types and different storage conditions on physiological loss in weight was found to be increased with increase in storage period as presented in

Table 2. At the end of 2^{nd} day of storage, treatment combination of V_1S_1 recorded highest physiological loss in weight (13.11%) closely followed by V_4S_1 (12.45%) whereas lowest physiological loss in weight was recorded by V_5S_3 (2.76%) which was closely followed by V_4S_3 (2.78%). On 6^{th} day of storage, V_2S_3 recorded highest physiological loss in weight (9.73%) closely followed by V_4S_3 (9.71%). On 8^{th} day of storage, V_1S_3 recorded highest physiological loss in weight (11.21%) followed by V_3S_3 (9.47%) whereas the least PLW was recorded by V_5S_3 (8.25%).

The highest PLW was recorded in the primary processed vegetables stored at ambient storage than ZECC and RS. The similar results were also reported by Chauhan (1981) in vegetables, Waskar *et al*. (1999) in bottle gourd fruits and Negi and Roy (2004) leafy vegetables. The least PLW was recorded in refrigerated storage as it had highest humidity and lower temperature. Weight loss is a very important factor as it is associated with economic issues and generally weight loss more than 5-10 % reduces the market value of vegetables (Brown and Bourne, 2002). Water loss in vegetables is determined by many factors, the most important of which is the resistance exerted by the outer periderm or cuticle movement of water vapour due to transpiration as reported by Ben-Yehoshua (1987). The temperature and relative humidity must be controlled for preventing the moisture loss of vegetables as reported by Thompson (2004). The present findings are in comparable with Kulkarni (2015) in fenugreek and spinach, Sharangi *et al.*, (2015) in coriander, Ambuko *et al*. (2017) in leafy amaranthus and Indore *et al*. (2017) in okra, and under different storage conditions.

Yellowing (%)

Yellowing percentage calculated by recording the observations at every alternate day from the zero day of storage till the end of storage life. Slightly yellowed leaves were sorted from the samples and yellowing percentage was calculated. The data depicted in Table 2 emphasized on the findings occurred while recording the yellowing of different leafy vegetables used for investigation.

It is clearly seen from the data presented in Table 2 that individual types of vegetable showed significant effect on yellowing under different storage conditions. On 2^{nd} day of storage, V_1 recorded highest yellowing (4.72 %) followed by V_2 (2.97 %) and lowest yellowing was recorded by V_4 (1.43 %). At the end of 6^{th} day of storage, V_1 marked the yellowing of 4.89% which was highest among all vegetables while lowest yellowing was recorded by V_4 (1.64 %). On the end of 8^{th} day of storage, V_1 recorded the highest yellowing (5.07 %) and least yellowing was depicted in V_5 (2.03 %). Further, it was noticed that the yellowing percentage was increased throughout the storage period irrespective of storage conditions.

The data presented in Table 2 gives an account of individual effect of different storage conditions on yellowing of different primary processed leafy vegetables was found to be significant. The storage condition S_1 recorded highest yellowing of 4.24 % and the lowest yellowing was recorded by S_3 (0.41 %) at the end of 2^{nd} day of storage. On 8^{th} day of storage, S_3 recorded the least yellowing (3.40 %) at refrigerated conditions thereafter samples were discarded. It was also revealed that, yellowing was increased as storage period advanced throughout the storage period. Faster rate of yellowing was occurred at room temperature followed by ZECC and refrigerated storage. The lowest rate of yellowing was recorded at refrigerated storage it might be due to prevalence high humidity and lower temperature as recorded by Hou *et al*. (2003) in spinach and findings of present investigation are in accordance with results reported by Reddy *et al*. (2013) in rajgira

(Fig. 1). With a brief glance on Table 2 it can be vividly perceived that, interaction effect of types of vegetable and different storage conditions on yellowing of primary processed leafy vegetables was found to be significant in all the treatment combinations. On 2^{nd} day of storage, V_1S_1 recorded highest yellowing (7.14%) followed by V_1S_2 (6.03%) and lowest yellowing was recorded by V_2S_3 (0.25%) while no yellowing was recorded by V_5S_3 at the end of 2^{nd} day of storage. At the end of 6^{th} of storage, highest yellowing was recorded by V_1S_3 (4.89 %) and lowest was recorded by V_4S_3 (1.64 %). At the end of 8^{th} day of storage, highest yellowing was recorded by V_1S_3 (5.07 %) and lowest yellowing was recorded by V_5S_3 (2.03 %), followed by V_3S_3(3.11 %). As yellowing is an inevitable symptom of senescence in vegetables and hence, it is most important factor influenced the shelf- life as well as overall acceptability of vegetables. The trend of increase in yellowing of all the samples of vegetable irrespective of storage conditions was noticed. The results of present findings are in parallel with the results recorded by Reddy (2013) in rajgira.

Decay (%)

Data presented in Table 3 gives an account of decay of primary processed leafy vegetables was differed significantly. It was found that, the increasing trend in decay was observed in primary processed leafy vegetables under various storage conditions throughout the storage period irrespective of vegetables. On 2^{nd} day of storage, V_1 recorded highest decay of 2.62 % and lowest was noticed in V_4 (1.84 %). At the end of 6^{th} day of storage, V_1 recorded highest decay of 2.93 % whereas lowest decay was observed in V_4 (2.36 %). On 8^{th} day of storage, V_1 recorded highest decay (3.43 %) and closely followed by V_3 (3.03 %) and lowest decay was noted in V_5 (2.89 %) and samples were discarded due to market unacceptability.

With a short glance in Table 3 it is revealed that individual effect of different storage conditions on decay of vegetables was found to be significant. S_1 had highest temperature and lowest humidity which leads to faster rate of respiration among the vegetables and resulted into more decay and in the short storage life. Comparatively decay was lower in S_2 than S_1, as it had lower temperature and higher humidity than RT i.e. S_1 recorded the decay of 3.82 % on 2^{nd} day of storage. On 6^{th} day and 8^{th} day of storage, S_3 recorded decay of 2.70 and 3.12 %, respectively. Among the storage conditions, S_3 was depicted lowest decay as it had highest humidity and no fluctuation of temperature which restrict the respiration rate and hence lower decay in vegetables at the end of storage life.

It was also noticed that, the interaction effect of different storage conditions and types of vegetable on decay in all treatments was found to be significant. On 2^{nd} day of storage, of V_1S_1 recorded highest decay (5.20 %) followed by V_3S_1 (4.01 %) whereas lowest decay was recorded by treatment V_4S_3 (0.65 %) followed by V_5S_3 (0.90 %). At the end of 6^{th} day of storage, V_3S_3 recorded highest decay (2.93 %) followed by V_2S_3 (2.83 %) and lowest decay was recorded by V_4S_3 (2.36 %) followed by V_5S_3 (2.57 %). On 8^{th} day of storage, of V_1S_3 recorded highest decay (3.43%) whereas lowest decay was recorded by V_5S_3 (2.89%). Among all treatment combinations, V_5S_3 recorded the least decay and responded better to have more shelf life. The increasing trend with respect to decay of primary processed leafy vegetables was noticed during storage irrespective of types of vegetable and storage conditions. The low levels of oxygen favours fermentation processes which might cause the formation of the acetaldehyde and off flavour compounds which may cause decay as reported by Kaur and Kapoor (2000) in minimally processed fruits and vegetables. Quadri *et al.* (2015)

observed that, leafy vegetables have an array of advantages but are highly perishable in nature which leads them to higher decay. The results of present findings are in accordance with the results reported by Kulkarni (2015) in spinach and fenugreek and Sharangi *et al*. (2015) in coriander.

Shriveling (%)

The data shown in Table 3 gives an account of shriveling (%) of different primary processed leafy vegetables under different storage conditions was found to be influenced significantly. The highest shriveling percentage was recorded by V_2 (8.19 %) closely followed by V_5 (7.98 %) whereas lowest shriveling was noticed in V_3 (6.52 %) and V_1 (6.97 %) at the end of 2nd day of storage. On 6th day of storage, V_2 recorded the highest shriveling (10.12 %) and lowest was observed in V_1 (8.15%). On 8th day of storage, V_1 recorded highest shriveling (11.13%) and lowest was recorded by V_5 (9.86 %). The shriveling percentage of primary processed leafy vegetables showed the increasing trend in all the vegetables under study.

Individual effect of different storage conditions on shriveling was found to be significant as emphasized in Table 3. The data revealed that, S_1 recorded the highest percentage of shriveling due to high temperature while S_2 recorded comparatively less shriveling than S_1 and higher than S_3. The storage conditions S_3 had highest humidity and lowest temperature than other storage conditions hence recorded lowest shriveling. On 2nd day of storage, the shriveling percentage was found to be maximum in S_1 (12.09 %) followed by S_2 (7.03 %) and S_3 (3.06 %). The samples stored at S_3condition recorded the shriveling of 11.09 % at the end 8th day of storage. Rate of shriveling was faster at room temperature (S_1) followed by ZECC (S_2) and refrigerated storage (S_2). The shriveling percentage showed the increasing trend during the storage irrespective of storage conditions. Similar results were also recorded by Garande (1992) in jamun fruits.

The data presented in Table 3 gives a clear representation of interactions of different storage conditions and vegetable types showed increasing trend with respect to shriveling in all vegetables under study. On 2nd day of storage, V_5S_1recorded highest shriveling (14.11 %) followed by V_1S_1 (12.86 %) whereas lowest shriveling was recorded by V_5S_3 (1.96 %) followed by V_4S_3 (2.16 %). On 6th day of storage, V_2S_3 recorded highest shriveling (10.12 %) followed by V_4S_3 (10.02 %) and lowest was recorded by V_1S_3 (8.15 %). On 8th day of storage, V_1S_3 recorded highest shriveling of 11.13 % and lowest was recorded by V_5S_3 (9.86 %). The shriveling of primary processed leafy vegetables was found to be increased during the storage period irrespective of types of vegetable and storage conditions. The results of present investigation are in close conformity with the results of earlier research workers such as Garande (1992) in jamun fruits and Sharangi *et al.* (2015) in coriander.

Moisture (%)

The data depicted in Table 4 clearly indicated that the moisture content of primary processed vegetables exhibited the decreasing trend throughout the storage period irrespective of types of vegetable and storage conditions.

The moisture content of primary processed vegetable was found to be differed significantly among the different vegetables. Initially, highest moisture content was recorded in V_3 (94.00 %) followed by V_2 (92.24 %) whereas the lowest was noticed in V_5 (87.55 %). It was clearly seen that the vegetables which had thick and fleshy cuticle were contained highest moisture percentage and the vegetables which had thin cuticle were recorded minimum moisture percentage. At the end of shelf life moisture content was found to be highest in V_3 (85.65 %) whereas the lowest moisture content was noticed in V_5 (82.25 %). It was also seen that the least moisture loss was recorded in V_5 (5.30 %) whereas the highest moisture loss was observed in V_2 (8.72 %).

The data presented in Table 4 clearly indicated that, the moisture content was found to be decreased during storage period irrespective of storage conditions. The lowest moisture loss was noticed in S_3 (4.24 %) whereas the highest moisture loss was observed in S_1 (10.35 %).

The data regarding the interaction effect of types of vegetable and different storage conditions reveals that, the highest moisture content was recorded by V_3S_3(90.00 %) closely followed by V_2S_3(87.20 %) whereas lowest content of moisture was observed in V_1S_1 (80.04 %) at the end of shelf life. It was found that the per cent moisture loss in primary processed leafy vegetables was ranged from 3.31 % (V_5S_3) to 12.86 % (V_3S_1). The moisture percentage of primary processed vegetables was found to be decreased irrespective of vegetable types and storage conditions as storage period enhanced. The lowest moisture loss in the treatment V_5S_3 is might be due to the thick and fleshy cuticle of rajgira as compared to the remaining vegetables prevalence of low temperature and high humidity under refrigerated conditions resulted in less moisture loss. Similar results were also reported by Komolafe and Idah (2008) in okra, Kulkarni (2015) in fenugreek and spinach Patil (2016) in lettuce.

Total Mineral Content (%)

The data with respect to effect of types of vegetable and storage conditions have been presented in Table 4. From this data it is clearly seen that, the total mineral content of primary processed leafy vegetables was significantly influenced by types of vegetables and storage conditions.

The primary processed leafy vegetables showed significant variation in the total mineral content and was found to be ranged in between 22.03 % (V_5) to 27.57 % (V_1). At the end of storage period, highest total mineral content was recorded in V_3 (20.86 %) followed by V_1 (20.00 %) whereas lowest total mineral content was recorded by V_5 (14.95 %). Similarly, highest retention of total minerals content was observed in V_3 (82.87 %) and lowest was noticed in V_5(67.86 %).

The data with respect to effect of storage conditions on the total mineral content of vegetables depicted in Table 3. The data revealed that, the total mineral content was found to be decreased irrespective of storage conditions. The highest total mineral content and its retention was observed under S_3 (20.86 % and 86.37 %, respectively) followed by S_2 (18.79 % and 77.80 %, respectively) and S_1 (15.11 and 62.56 %, respectively).

The data regarding interaction effect of types of vegetable and storage conditions on total mineral content have been presented in Table 4. It is clearly seen from the data that, the total mineral content of primary processed leafy vegetables was found to be decreased during storage period irrespective of storage conditions and types of vegetable. The highest total mineral content was recorded by V_1S_3 (25.23 %) followed by V_1S_2 (22.00 %) whereas lowest total mineral content was observed in V_5S_1 (12.23 %) followed by V_1S_1 (12.77 %) at the end of storage period. Similarly, the retention percentage of total mineral content was found to be maximum in V_1S_3 (91.51 %) followed by V_2S_3 (89.52 %) whereas lowest retention of total mineral content was recorded by V_1S_1 (46.31 %) and

V_5S_1 (55.51 %). A declining trend in total mineral content of primary processed leafy vegetables was observed in all the samples during storage irrespective of types of vegetable and storage conditions. The results of present findings are in concurs with the results of Patil (2016) in minimally processed lettuce.

Chemical constituent/traits

During the present investigation of physical parameters such as moisture (%), total mineral (%), ascorbic acid (mg/100g) and total chlorophyll contents (mg/100g) were estimated at initial and at termination of different treatments i.e. end of storage life. The results with respect to chemical constituents of primary processed leafy vegetables were significantly influenced by types of vegetable and storage conditions.

Ascorbic acid (mg/100g)

The data presented in Table 5 revealed that the ascorbic acid content was found to be differed significantly among the different vegetables under study. It was also noticed that, ascorbic acid content was decreased as storage period advanced in all the vegetables. Initially, among all the vegetables, V_2 recorded highest amount of ascorbic acid content (86.73 mg/100 g) followed by V_1 (80.68 mg/100 g) whereas lowest ascorbic acid was observed in V_5 (40.93 mg/100 g). At the end of storage period, highest ascorbic acid content was recorded in V_2 (62.77 mg/100 g) followed by V_1(57.67 mg/100 g) whereas the lowest was recorded by V_3(23.80 mg/100 g). Similarly, the highest retention of ascorbic acid was noticed in V_2 (72.37 %) followed by V_1 (71.47 %) and lowest retention was recorded in V_3 (47.10 %) followed by V_4 (53.75 %).

It was also found that, at the end of storage life, among the storage conditions, S_3 recorded highest ascorbic acid content (52.90 mg/100 g) followed by S_2 (40.20 mg/100 g) whereas lowest was noticed in S_1 (26.04 mg/100 g). Similarly, the highest retention of ascorbic acid was recorded in S_3 (84.31 %) and lowest retention was recorded by S_1 (41.50 %). Trend of decrease in ascorbic acid content was recorded throughout the storage period irrespective of storage conditions. Similar findings were also reported by Yadav and Sehgal (1997) who stated the ascorbic acid content of fenugreek was 220.97 mg/100g and Kulkarni (2015) in fenugreek and spinach.

The data presented in Table 5 reveals that, the ascorbic acid content of primary processed leafy vegetables was significantly differed among the different vegetables irrespective of storage conditions. At the end of storage life, highest ascorbic acid was recorded in V_2S_3 (75.00 mg/100 g) followed by V_1S_3 (71.07 mg/100 g) and lowest was recorded by V_3S_1 (10.63 mg/100 g) followed by V_4S_1 (11.65 mg/100g). At the end of storage life, the highest retention of ascorbic acid was recorded in V_1S_3 (88.86 %) followed by V_2S_3 (86.47 %) whereas lowest was observed in V_3S_1 (21.03%) followed by V_4S_1 (21.24%). The decreasing trend with respect of ascorbic acid content of primary processed leafy vegetables under different storage conditions was found. This may be due to increase in storage time and respiration had played important role in ascorbic acid reduction as reported by Sharma *et al*. (2011) in minimally processed vegetables. The stability of ascorbic acid is generally enforced by maintaining low temperature during storage (Fennema, 1996). The loss in ascorbic acid content is attributed to both, temperature and water loss (Kader, 2002). The results of present findings are in close conformity with findings of Kulkarni (2015) in fenugreek, Patil (2016) in lettuce and Indore *et al*. (2017) in okra

Total chlorophyll content (mg/100 g)

The data presented in Table 5 clearly indicated that, the total chlorophyll content of primary processed leafy vegetables was significantly influenced by the types of vegetable and storage conditions. It was found that the total chlorophyll content of primary processed leafy vegetables exhibited a decreasing trend throughout the storage period irrespective of types of vegetable and storage conditions.

It was also noticed that, the total chlorophyll content of primary processed leafy vegetables was decreased throughout the storage period irrespective of types of vegetable (Table 5). Initially, the chlorophyll content was ranged from 53.24 mg/100 g (V_2) to 90.58 mg/100 g (V_1). At the end of storage period, highest total chlorophyll content was recorded in V_4 (72.15 mg/100 g) followed by V_1 (67.64 mg/100 g) whereas lowest was noticed in V_2 (38.91 mg/100 g) followed by V_3 (56.81 mg/100 g). Further, it was also found that, highest retention of chlorophyll content was recorded in V_5 (87.83 %) and the lowest was recorded in V_3 (68.54 %) at the end of storage life.

It was noticed that, the individual effect of storage conditions on total chlorophyll content was found to be significant and showed decreasing trend during storage irrespective of storage conditions. The rate of reduction in total chlorophyll content was faster at room temperature followed by ZECC and refrigerated storage. Initially, all the storage conditions recorded total chlorophyll as 77.77 mg/100 g and it was found to be gradually decreased during storage. The highest total chlorophyll content was recorded in S_3 (70.15 mg/100 g) whereas lowest total chlorophyll content was recorded in S_1 (46.66 mg/100 g) at the end of storage period. The per cent retention of total chlorophyll was highest in S_3 (90.20) and was lowest in S_1 (63.85).

Table.1 Distribution of weight into different parts of leafy vegetables and shelf life of primary processed leafy vegetables under different storage conditions

Sr. No.	Name of the Vegetable	Wt. of Inedible Portion(g)	Wt. of Edible Portion (g)	Edible Portion (%)	Shelf life in days under different storage conditions		
					RT	ZECC	RS
1	**Fenugreek (V_1)**	600.25	399.75	39.97	2	3	8
2	**Coriander (V_2)**	655.80	344.20	34.40	2	3	6
3	**Spinach (V_3)**	351.50	648.50	64.80	2	4	8
4	**Pokala (V_4)**	609.59	390.41	39.04	2	4	6
5	**Rajgira (V_5)**	408.50	591.50	59.15	2	4	8

RT - Room temperature
ZECC - Zero Energy Cool chamber
RS - Refrigerated storage

Table.2 Effect types of vegetable and storage conditions on physiological loss in weight (%) of primary processed leafy vegetables

Treatment	Physiological Loss in Weight (%)					Yellowing (%)				
	Storage period in days					Storage period in days				
	0	**2**	**4**	**6**	**8**	**0**	**2**	**4**	**6**	**8**
$V_1 S_1$	0	13.11	-	-	-	0	7.14	-	-	-
$V_1 S_2$	0	6.07	10.06	-	-	0	6.03	6.81	-	-
$V_1 S_3$	0	3.45	5.08	8.00	11.21	0	1.01	2.89	4.89	5.07
$V_2 S_1$	0	11.17	-	-	-	0	5.22	-	-	-
$V_2 S_2$	0	7.18	11.48	-	-	0	3.45	4.95	-	-
$V_2 S_3$	0	3.71	5.22	9.73	-	0	0.25	1.86	3.15	-
$V_3 S_1$	0	9.19	-	-	-	0	3.91	-	-	-
$V_3 S_2$	0	5.23	10.43	-	-	0	2.37	4.00	-	-
$V_3 S_3$	0	2.90	4.42	7.91	9.47	0	0.44	0.99	2.67	3.11
$V_4 S_1$	0	12.45	-	-	-	0	2.42	-	-	-
$V_4 S_2$	0	5.67	10.01	-	-	0	1.52	2.73	-	-
$V_4 S_3$	0	2.78	5.32	9.71	-	0	0.37	0.26	1.64	-
$V_5 S_1$	0	8.32	-	-	-	0	2.50	-	-	-
$V_5 S_2$	0	4.01	8.38	-	-	0	2.05	3.18	-	-
$V_5 S_3$	0	2.76	4.58	7.33	8.25	0	0.00	0.34	1.95	2.03
SE±		**0.0987**	**0.0339**	**0.0069**	**0.0039**		**0.0772**	**0.0068**	**0.0042**	**0.0092**
CD at 1%		**0.3840**	**0.1317**	**0.0270**	**0.0153**		**0.3002**	**0.0266**	**0.0164**	**0.0359**
V_1	0	7.54	7.57	8.00	11.21	0	4.72	4.85	4.89	5.07
V_2	0	7.35	8.35	9.73	-	0	2.97	3.03	3.15	-
V_3	0	5.78	7.43	7.91	9.47	0	2.24	2.49	2.67	3.11
V_4	0	6.97	7.66	9.71	-	0	1.43	1.49	1.64	-
V_5	0	5.03	6.48	7.33	8.25	0	1.52	1.76	1.95	2.03
SE ±		**0.0570**	**0.0196**	**0.0040**	**0.0023**		**0.0446**	**0.0039**	**0.0024**	**0.0053**
CD at 1%		**0.2217**	**0.0760**	**0.0156**	**0.0089**		**0.1700**	**0.0153**	**0.0095**	**0.0207**
S_1	0	10.85	-	-	-	0	4.24	-	-	-
S_2	0	5.63	10.07	-	-	0	3.08	4.18	-	-
S_3	0	3.12	4.92	8.54	9.64	0	0.41	1.27	2.86	3.40
SE ±		**0.0442**	**0.0151**	**0.0031**	**0.0018**		**0.0345**	**0.0031**	**0.0019**	**0.0041**
CD at 1%		**0.1717**	**0.0589**	**0.0121**	**0.0069**		**0.1304**	**0.01**	**0.0073**	**0.0161**

'-' Indicates termination of treatment

V_1- Fenugreek, **V_2** - Coriander, **V_3** - Spinach, **V_4** -Pokala, **V_5** -Rajgira
S_1 - Room temperature, **S_2** _ ZECC, **S_3** - Refrigerated storage

Table.3 Effect types of vegetable and storage conditions on physiological loss in weight (%) of primary processed leafy vegetables

Treatment	Decay (%)					Shriveling (%)				
	Storage period in days					Storage period in days				
	0	2	4	6	8	0	2	4	6	8
$V_1 S_1$	0	5.20	-	-	-	0	12.86	-	-	-
$V_1 S_2$	0	2.05	4.32	-	-	0	5.03	10.04	-	-
$V_1 S_3$	0	0.90	1.34	2.93	3.43	0	3.03	5.03	8.15	11.13
$V_2 S_1$	0	3.03	-	-	-	0	11.41	-	-	-
$V_2 S_2$	0	2.72	3.21	-	-	0	7.79	10.51	-	-
$V_2 S_3$	0	1.22	2.03	2.83	-	0	5.38	8.00	10.12	-
$V_3 S_1$	0	4.01	-	-	-	0	10.57	-	-	-
$V_3 S_2$	0	2.01	4.10	-	-	0	6.21	11.05	-	-
$V_3 S_3$	0	0.99	1.45	2.79	3.03	0	2.77	6.33	9.14	10.90
$V_4 S_1$	0	3.25	-	-	-	0	11.51	-	-	-
$V_4 S_2$	0	1.63	3.52	-	-	0	8.25	14.25	-	-
$V_4 S_3$	0	0.65	0.98	2.36	-	0	2.16	5.07	10.02	-
$V_5 S_1$	0	3.61	-	-	-	0	14.11	-	-	-
$V_5 S_2$	0	2.46	3.98	-	-	0	7.88	12.71	-	-
$V_5 S_3$	0	0.90	0.92	2.57	2.89	0	1.96	4.17	9.47	9.86
SE±		**0.0786**	**0.0148**	**0.0059**	**0.0042**		**0.0366**	**0.0146**	**0.0069**	**0.00**
CD at 1%		**0.3057**	**0.0575**	**0.0229**	**0.0164**		**0.1425**	**0.0566**	**0.0268**	**0.0100**
V_1	0	2.62	2.83	2.93	3.43	0	6.97	7.54	8.15	11.13
V_2	0	2.32	2.62	2.83	-	0	8.19	9.26	10.12	-
V_3	0	2.34	2.72	2.79	3.03	0	6.52	8.69	9.14	10.90
V_4	0	1.84	2.25	2.36	-	0	7.31	9.66	10.02	-
V_5	0	2.44	2.45	2.57	2.89	0	7.98	8.44	9.47	9.86
SE ±		**0.0454**	**0.0085**	**0.0034**	**0.0024**		**0.0212**	**0.0084**	**0.0040**	**0.0012**
CD at 1%		**0.1765**	**0.0332**	**0.0132**	**0.0095**		**0.0823**	**0.0327**	**0.0155**	**0.0047**
S_1	0	3.82	-	-	-	0	12.09	-	-	-
S_2	0	2.17	3.80	-	-	0	7.03	11.71	-	-
S_3	0	0.94	1.34	2.70	3.12	0	3.06	5.72	9.38	11.09
SE ±		**0.0352**	**0.0066**	**0.0026**	**0.0019**		**0.0164**	**0.0065**	**0.0031**	**0.0009**
CD at 1%		**0.1367**	**0.0257**	**0.0103**	**0.0073**		**0.0637**	**0.0253**	**0.012**	**0.0037**

'-' Indicates termination of treatment

V_1- Fenugreek, **V_2** - Coriander, **V_3** - Spinach, **V_4** -Pokala, **V_5** -Rajgira
S_1 - Room temperature, **S_2** _ ZECC, **S_3** - Refrigerated storage

Table.4 Effect of types of vegetable and storage conditions on moisture content of primary processed leafy vegetables

Treatment	Moisture (%)			Total mineral content (%)		
	Initial	At termination	% Loss	Initial	At termination	% Retention
$V_1 S_1$	90.77	80.04	10.73	27.57	12.77	46.31
$V_1 S_2$	90.77	83.79	6.98	27.57	22.00	79.79
$V_1 S_3$	90.77	85.80	4.97	27.57	25.23	91.51
$V_2 S_1$	92.24	81.04	11.20	23.20	16.03	69.09
$V_2 S_2$	92.24	82.32	9.92	23.20	19.23	82.88
$V_2 S_3$	92.24	87.20	5.04	23.20	20.77	89.52
$V_3 S_1$	94.00	81.14	12.86	25.17	20.03	79.57
$V_3 S_2$	94.00	85.80	8.21	25.17	20.83	82.75
$V_3 S_3$	94.00	90.00	4.00	25.17	21.72	86.29
$V_4 S_1$	90.17	80.61	9.55	22.77	14.47	63.54
$V_4 S_2$	90.17	82.44	7.72	22.77	16.63	73.03
$V_4 S_3$	90.17	86.28	3.89	22.77	19.22	84.40
$V_5 S_1$	87.55	80.12	7.43	22.03	12.23	55.51
$V_5 S_2$	87.55	82.39	5.16	22.03	15.27	69.31
$V_5 S_3$	87.55	84.24	3.31	22.03	17.37	83.38
SE±	**0.1276**	**0.2091**	--	**0.0298**	**0.0244**	
CD at 1%	**0.4694**	**0.8130**	--	**0.1159**	**0.0951**	
V_1	90.77	83.21	7.56	27.57	20.00	72.54
V_2	92.24	83.52	8.72	23.20	18.68	80.51
V_3	94.00	85.65	8.35	25.17	20.86	82.87
V_4	90.17	83.11	7.06	22.77	16.77	73.64
V_5	87.55	82.25	5.30	22.03	14.95	67.86
SE±	**0.0737**	**0.1207**	--	**0.0172**	**0.0141**	
CD at 1%	**0.2866**	**0.4694**	--	**0.0669**	**0.0549**	
S_1	90.94	80.59	10.35	24.15	15.11	62.56
S_2	90.94	83.35	7.59	24.15	18.79	77.80
S_3	90.94	86.70	4.24	24.15	20.86	86.37
SE±	**0.0571**	**0.0935**	--	**0.0133**	**0.0109**	
CD at 1%	**0.2220**	**0.3636**	--	**0.0519**	**0.0425**	

'-' Indicates termination of treatment

V_1- Fenugreek, V_2 - Coriander, V_3 - Spinach, V_4 -Pokala, V_5 -Rajgira
S_1 - Room temperature, S_2 _ ZECC, S_3 - Refrigerated storage

Table.5 Effect of types of vegetable and storage conditions on moisture content of primary processed leafy vegetables

Treatment	Ascorbic acid content (mg/100g)			Total chlorophyll content (mg/100g)		
	Initial	At termination	% Retention	Initial	At termination	% Retention
$V_1 S_1$	80.68	40.91	50.70	90.58	55.93	61.74
$V_1 S_2$	80.68	61.02	75.63	90.58	68.88	76.04
$V_1 S_3$	80.68	71.07	88.86	90.58	78.11	86.23
$V_2 S_1$	86.73	50.65	58.39	53.24	30.67	57.60
$V_2 S_2$	86.73	62.66	72.24	53.24	41.79	78.49
$V_2 S_3$	86.73	75.00	86.47	53.24	44.28	83.17
$V_3 S_1$	50.53	10.63	21.03	83.02	43.31	52.16
$V_3 S_2$	50.53	20.25	40.07	83.02	55.27	66.57
$V_3 S_3$	50.53	40.51	80.17	83.02	71.85	86.54
$V_4 S_1$	54.84	11.65	21.24	88.02	61.31	69.65
$V_4 S_2$	54.84	32.81	59.82	88.02	72.31	82.15
$V_4 S_3$	54.84	43.98	80.19	88.02	82.82	94.04
$V_5 S_1$	40.93	16.37	39.99	73.98	57.10	77.18
$V_5 S_2$	40.93	24.25	59.24	73.98	64.17	86.73
$V_5 S_3$	40.93	33.92	82.87	73.98	69.17	93.49
SE±	**0.4302**	**0.3344**	--	**0.3322**	**0.3402**	
CD at 1%	**1.6729**	**1.3006**	--	**1.2921**	**1.3232**	
V_1	80.68	57.67	71.47	90.58	67.64	74.67
V_2	86.73	62.77	72.37	53.24	38.91	73.08
V_3	50.53	23.80	47.10	83.02	56.81	68.54
V_4	54.84	29.48	53.75	88.02	72.15	81.97
V_5	40.93	24.85	60.71	73.98	64.98	87.83
SE±	**0.2484**	**0.1931**	--	**0.1918**	**0.1964**	
CD at 1%	**0.9659**	**0.7509**	--	**0.7460**	**0.7640**	
S_1	62.74	26.04	41.50	77.77	49.66	63.85
S_2	62.74	40.20	64.07	77.77	60.48	77.76
S_3	62.74	52.90	84.31	77.77	70.15	90.20
SE±	**0.1924**	**0.1496**	--	**0.1486**	**0.1522**	
CD at 1%	**0.7481**	**0.5817**	--	**0.5778**	**0.5918**	

'-' Indicates termination of treatment

V_1- Fenugreek, **V_2** - Coriander, **V_3** - Spinach, **V_4** -Pokala, **V_5** -Rajgira
S_1 - Room temperature, **S_2** _ ZECC, **S_3** - Refrigerated storage

Table.6 Effect types of vegetable and storage conditions on colour and appearance of primary processed leafy vegetables

Treatment	Colour					Appearance				
	Storage period in days					Storage period in days				
	0	**2**	**4**	**6**	**8**	**0**	**2**	**4**	**6**	**8**
V_1 S_1	9	5.83	-	-	-	9	8.17	-	-	-
V_1 S_2	9	7.17	6.5	-	-	9	7.80	5.67	-	-
V_1 S_3	9	8.00	8.33	7.42	6.08	9	7.50	7.83	7.42	6.58
V_2 S_1	9	6.33	-	-	-	9	6.00	-	-	-
V_2 S_2	9	6.83	6	-	-	9	6.83	6.08	-	-
V_2 S_3	9	8.17	7.83	7.42	-	9	8.17	7.58	6.92	-
V_3 S_1	9	7.67	-	-	-	9	7.13	-	-	-
V_3 S_2	9	7.83	5.92	-	-	9	7.58	6.33	-	-
V_3 S_3	9	8.33	7.73	7.67	6.58	9	8.17	8.08	6.33	6.58
V_4 S_1	9	6.25	-	-	-	9	5.67	-	-	-
V_4 S_2	9	6.08	7.17	-	-	9	6.58	6.83	-	-
V_4 S_3	9	7.83	7.33	6.75	-	9	7.75	7.5	6.98	-
V_5 S_1	9	6.25	-	-	-	9	6.25	-	-	-
V_5 S_2	9	8.27	8.23	-	-	9	7.80	7.83	-	-
V_5 S_3	9	8.67	7.80	7.00	6.75	9	8.27	7.92	7.40	7.15

'-' Indicates termination of treatment

V_1- Fenugreek, **V_2 -** Coriander, **V_3 -** Spinach, **V_4 -**Pokala, **V_5 -**Rajgira
S_1 - Room temperature, **S_2** _ ZECC, **S_3 -** Refrigerated storage

Table.7 Effect types of vegetable and storage conditions on colour and appearance of primary processed leafy vegetables

Treatment	Aroma					Overall acceptability				
	Storage period in days					Storage period in days				
	0	2	4	6	8	0	2	4	6	8
V_1 S_1	9	5.00	-	-	-	9	5.50	-	-	-
V_1 S_2	9	6.33	6.67	-	-	9	6.75	5.23	-	-
V_1 S_3	9	7.67	8.00	7.08	6.33	9	7.88	7.86	7.13	6.33
V_2 S_1	9	6.83	-	-	-	9	6.17	-	-	-
V_2 S_2	9	7.17	7.17	-	-	9	6.96	6.27	-	-
V_2 S_3	9	7.67	7.67	7.17	-	9	8.04	7.64	7.04	-
V_3 S_1	9	6.17	-	-	-	9	7.03	-	-	-
V_3 S_2	9	6.25	5.98	-	-	9	7.24	6.12	-	-
V_3 S_3	9	7.83	7.50	6.83	6.17	9	8.14	7.78	6.95	6.37
V_4 S_1	9	6.83	-	-	-	9	6.39	-	-	-
V_4 S_2	9	6.67	6.17	-	-	9	6.87	6.62	-	-
V_4 S_3	9	7.58	7.00	6.08	-	9	7.56	7.43	6.51	-
V_5 S_1	9	6.25	-	-	-	9	6.25	-	-	-
V_5 S_2	9	7.88	7.50	-	-	9	8.01	7.78	-	-
V_5 S_3	9	8.17	7.58	6.75	6.35	9	8.35	7.96	7.33	6.74

'-' Indicates termination of treatment

V_1- Fenugreek, **V_2** - Coriander, **V_3** - Spinach, **V_4** -Pokala, **V_5** -Rajgira
S_1 - Room temperature, **S_2** _ ZECC, **S_3** - Refrigerated storage

Table.8 Effect of types of vegetable and storage conditions on total microbial count (log cfu/g) of primary processed leafy vegetables

Treatment	Total Microbial Count (log cfu/g)	
	Initial	**At termination**
$V_1 S_1$	7.55	7.68
$V_1 S_2$	7.55	7.60
$V_1 S_3$	7.55	7.47
$V_2 S_1$	7.45	7.55
$V_2 S_2$	7.45	7.49
$V_2 S_3$	7.45	7.41
$V_3 S_1$	7.35	7.55
$V_3 S_2$	7.35	7.46
$V_3 S_3$	7.35	7.36
$V_4 S_1$	7.28	7.62
$V_4 S_2$	7.28	7.49
$V_4 S_3$	7.28	7.42
$V_5 S_1$	6.76	7.35
$V_5 S_2$	6.76	7.13
$V_5 S_3$	6.76	7.01
SE± 1%	**0.0165**	**0.0031**
CD at 1%	**0.0640**	**0.0121**
V_1	7.55	7.58
V_2	7.45	7.48
V_3	7.35	7.45
V_4	7.28	7.51
V_5	6.76	7.24
SE± 1%	**0.0095**	**0.0018**
CD at 1%	**0.0370**	**0.0070**
S_1	7.29	7.66
S_2	7.29	7.57
S_3	7.29	7.47
SE± 1%	**0.0074**	**0.0014**
CD at1%	**0.0286**	**0.0054**

‘-‘ Indicates termination of treatment

V_1- Fenugreek, **V_2** - Coriander, **V_3** - Spinach, **V_4** -Pokala, **V_5** -Rajgira
S_1 - Room temperature, **S_2** _ ZECC, **S_3** - Refrigerated storage

Fig.1 Appearance life of primary processed leafy vegetables under different storage conditions

			
Plate : 1 Primary Processed Fenugreek (V_1) at RT 0, 2 DAS	**Primary Processed Fenugreek (V_1) at RT - 2 DAS**	**Primary Processed Fenugreek (V_1) at ZECC at 3 DAS**	**Primary Processed Fenugreek (V_1) at RS at 8 DAS**
			
Plate : 2 Primary Processed Coriander (V_2) at RT 0 days	**Primary Processed Coriander (V_2) at RT 2 Days**	**Primary Processed Coriander (V_2) at ZECC for 3 Days**	**Primary Processed Coriander (V_2) at RS for 6 DAS**
			
Primary processed Spinach (V_3) sample (0^{th} DAS)	**Primary processed Spinach (V_3) at TR on days**	**Primary processed Spinach (V_3) at ZECC for 3 days**	**Primary processed Spinach (V_3) at RS for 6 days**
			
Plate : 5 Primary processed Pokala (V_4) on 0daysts	**Primary processed Pokala (v_4) RT for 2 days**	**Primary processed Pokala (v_4) ZECC for 4 days**	**Prima Primary processed PokalaatnPokala RS for 6 days**

			
Plate : 6 Primary processed rajgira (V_5) (0^{th}	**Primary processed rajgira (V_5) at RT for 2 days**	**Primary processed rajgira (V_5) atZECC at 4 days**	**Primary processed rajgira (V_5) atRS at 8 days**

From the data presented in Table 5, it is clearly seen that, the total chlorophyll content was significantly influenced by the types of vegetable and storage conditions. At the end of storage period, V_4S_3 recorded highest total chlorophyll content (82.82 mg/100 g) followed by V_1S_3 (78.11 mg/100 g) whereas lowest was found in V_2S_1 (30.67 mg/100 g) followed by V_2S_2 (41.79 mg/100 g). The per cent retention of total chlorophyll content was found to be highest in V_4S_3 (94.04 %) followed by V_5S_3 (93.49 %) whereas lowest retention was recorded in V_3S_1 (52.16 %) followed by V_1S_1 (61.74 %). All the treatments at refrigerated storage conditions showed better retention of chlorophyll content. The low oxygen and high carbon dioxide concentration can prevent chlorophyll degradation. Presence of vents has failed to increase carbon dioxide concentration, thus leading to higher amount of degradation of chlorophyll. The principle causes of the breakdown of chlorophyll are pH changes mainly due to leakage of organic acids from the vacuole, oxidative system and chlorophyllases (Wills *et al.,* 1989). The decreasing trend of chlorophyll content with advancement of storage has been reported Abe and Watada (1991) and Rai *et al*. (2009) in shredded cabbage. The results of present findings are in close conformity with findings of Kulkarni (2015) who reported that, the total chlorophyll content in fenugreek and spinach was found to be decreased with increase in temperature and decrease in humidity.

Sensorial evaluation of primary processed leafy vegetables

Colour

The data presented in Table 6 clearly indicated that, the sensorial score for colour of primary processed leafy vegetables was found to be decreased during the storage period irrespective of storage conditions and types of vegetable. The highest score for colour was recorded by V_5S_3 (8.67) whereas lowest score for colour was recorded in V_1S_1 (5.83) closely followed by V_4S_2 (6.08) and V_5S_1 (6.25) at the end of 2^{nd} day of storage. On 6^{th} day of storage treatment combination V_3S_3 recorded highest score (7.67) whereas lowest score for colour was recorded in V_4S_3 (7.00).

On 8^{th} day of storage, V_5S_3 recorded highest score (6.75) while V_1S_3 recorded lowest score (6.08) for colour. Similar results were reported by Sharangi *et al.,* (2015) in coriander, Patil (2016) in lettuce and Indore *et al.* (2017) in okra who stated that the vegetables having good total chlorophyll content had recorded higher score for colour. Storage conditions were played vital role in getting score for colour. The change in colour of leaves adversely affects the quality and market acceptance which is more under ambient storage and packaging material used. The decreasing trend was found in colour throughout the storage period irrespective of types of vegetables and storage conditions.

Appearance

The data with respect to effect of types of vegetable and storage conditions on sensorial score for appearance of primary processed leafy vegetables have been presented in Table 6. The data revealed that, highest score for appearance was recorded by the treatment combination of V_5S_3 (8.27) whereas lowest score was recorded in V_4S_1 (5.67) on 2^{nd} day of storage. On 6^{th} day of storage, the score for appearance was ranged in between 6.33 (V_3S_3) to 7.42 (V_1S_3). The results of present findings are in concurs with earlier research work reported by Narang *et al.* (2016) in fenugreek and Patil (2016) in lettuce.

Aroma

The data with respect to interaction of types of vegetable and storage conditions on sensorial score for aroma have been depicted in Table 7. The storage conditions showed marked effect on aroma of the samples used for investigation. On 2^{nd} day of storage, V_5S_3 (8.17) recorded highest score for aroma followed by treatment V_5S_2 (7.88) and lowest score was recorded by V_1S_1 (5.00) followed by V_3S_1 (6.17). On 6^{th} day of storage, highest score for aroma was noticed in V_2S_3 (7.17) closely followed by V_1S_3 (7.08) whereas lowest score for aroma was recorded by V_4S_3 (6.08). At the end of 8^{th} day of storage, V_5S_3 recorded highest score of 6.35 and lowest score was recorded by V_3S_3 (6.17). In all the treatments, decreasing trend with respect to score for aroma was found throughout the storage period. At S_1 storage conditions, aroma was fading out more rapidly than S_2 and S_3. The S_3storage conditions had highest score for aroma and more marketable acceptability than S_1 and S_2conditions. The S_3 conditions had highest humidity and lowest temperature which preserves aroma of vegetables for longer. The similar results were recorded by Brar *et al.* (2013) in fenugreek who stated that perforations did not allowed the accumulation of O_2 and CO_2 and resulted into better retention of aroma.

Overall acceptability

Overall acceptability of primary processed leafy vegetables was recorded according to the score gained by the other sensorial characters which were used to evaluate colour, appearance, texture, aroma recorded and presented in Table 7. It was noticed that, as storage period advanced overall acceptability of vegetables decreased irrespective of types of vegetables and storage conditions. The data revealed that the treatment combination of V_5S_3 recorded highest score for overall acceptability (8.35) followed by V_3S_3(8.14) whereas lowest score was recorded by V_1S_1(5.50) followed by V_2S_1(6.17) on 2^{nd} day of storage. On 6^{th} day of storage, V_5S_3 recorded highest score (7.33) and lowest score was recorded by V_4S_3 (6.51). Similar trend was found on 8^{th} day of storage where highest score for overall acceptability was recorded by V_5S_3 (6.74) followed by V_3S_3 (6.37) and V_1S_3 (6.33) as the samples were stored under S_3 conditions.

Further, it was found that refrigerated storage was found to be effective in maintaining the colour, appearance, texture, aroma throughout the storage period and maximum overall acceptability might be due to low temperature during storage which led to reduced minimum moisture and physiological loss in weight. The results of present findings are in accordance with results reported by Kim *et al.* (2004) in salad savoy, Jha and Matsuoka, (2005) in tomato and Indore *et al*. (2017) in okra.

Shelf life

The primary processed leafy vegetables packed in 200-gauge polyethylene bags with 2 % vents were stored at different storage conditions and recorded the variation in the shelf-life primary processed leafy vegetables under different storage condition as depicted in Table 1.

From the data represented in Table 1, it is clearly seen that, all the vegetables under study could be stored up to 2 days at RT. It was also found that fenugreek and coriander recorded shelf life of 3 days while spinach, pokala and rajgira recorded the shelf life up to 4 days when stored at zero energy cool chamber. The variation in shelf-life of primary processed vegetables stored at $S_1$and S_2may be due to lower temperature and higher humidity could be maintained in zero energy cool chamber than room temperature.

In general, all the samples of primary processed leafy vegetables stored at zero energy cool chamber were found to be fresh, attractive and have good consumer's acceptance at the end of shelf life than the samples stored at room temperature as reported by Garande (1992) in jamun fruits. Rayaguru *et al.* (2010) recorded that the shelf life of potato, tomato, brinjal, mango, banana and spinach could be extended up to 3-15 days in zero energy cool chamber than room temperature and this extended shelf life may be due to the cool chamber where average temperature of its environment can be lowered by less by 5-8 ^{0}C than the outside and maintained more than 90 % RH.

The highest shelf life of 8 days was recorded by fenugreek, spinach and rajgira while 6 days of shelf life was recorded by coriander and pokala when stored at refrigerated storage. This might be due to the steady maintained lower temperature and higher humidity than S_1 and S_2 conditions. The results of present findings are in concurs with the findings of Jaggi *et al.* (2005) in spinach and fenugreek, Patil (2016) in lettuce and Indore *et al*. (2017) in okra.

Total microbial count (log cfu /g)

The data presented in Table 8 clearly indicated that, storage conditions had significant effect on total microbial count in present investigation. Initially, V_1, V_2, V_3, V_4 and V_5 recorded 7.55, 7.45, 7.35, 7.28 and 6.76 log cfu/g of total microbial count, respectively. At the end of storage period, V_1 recorded highest microbial count (7.58 log cfu /g) followed by V_4 (7.51 log cfu/g) and lowest was recorded in V5 (7.24log cfu /g). Increasing trend in total microbial count was observed in all the vegetables irrespective of storage conditions.

Individual storage conditions had significant effect on total microbial count (Table 8). At the end of storage period, S_1 storage conditions showed highest microbial count (7.66 log cfu/g) followed by S_2, S_3whereas the S_3 storage conditions recorded lowest microbial count (7.47 log cfu/g). This might be due to low temperature and high humidity which restrict the growth of microbes and recorded lowest total microbial count.

Interaction of types of vegetables and storage conditions had significant effect on total microbial count as depicted in Table 8. The data revealed that increasing trend was noticed in total microbial count throughout the storage irrespective of types of vegetable and storage conditions. At the end of storage life, highest total microbial count was recorded V_1S_1 (7.68 log cfu/g) followed by V_1S_2 (7.60) whereas lowest microbial count was recorded in V_5S_3 and V_5S_2 as 7.01log cfu /g and 7.13log cfu /g, respectively. It was also found that microbial growth was limited at refrigerated storage (5±1°C) where low temperature during storage reduced respiration rate, senescence and retarded growth of spoilage micro-organisms while ZECC storage facilitated its proliferation. Patil (2016) recorded the least microbial count on lettuce at the end of 15 days of storage. The results of present findings are in conformity with the findings reported by Froder, *et al*. (2007) in vegetable salad and Zenoozian (2011) in leafy vegetables and Patil (2016) in lettuce.

In conclusion, the primary processed rajgira packed in 200-gauge polyethylene bag with 2% vents and stored at refrigerated storage (5±1°C), effectively restricted microbial growth maintained physico-chemical attributes with minimum physiological loss in weight and % moisture loss resulted in enhanced appearance, texture with highest overall acceptability. Among the all leafy vegetables, the rajgira showed lesser loss in physico-chemical parameters than other remaining vegetables irrespective of storage conditions. Among the three storage conditions refrigerated storage (5±1°C) was found to be the best storage condition for better retention of physico-chemical qualities of different leafy vegetables as compared to zero energy cool chamber and room temperature. The shelf life of fenugreek, spinach and rajgira was extended up to 8 days whereas coriander and pokala recorded 6 days shelf life when stored under refrigerated storage (5±1°C).

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