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Effect of packaging material on physico-chemical properties of minimally processed shredded cabbage stored under refrigerator condition

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Abstract
The present study entitled "Effect of packaging material on Physico- chemical properties of Minimally Processed shredded cabbage stored under refrigerator condition" was conducted in the Laboratory of Vegetable Science of Indira Gandhi Krishi Vishwavidyalaya, Raipur (C.G.) during the year 2022-23. A study was conducted to examine the physico-chemical attributes of minimally processed shredded cabbage when packed in three different packaging materials, such as a 200-gauge, 400-gauge polyethylene bag and punnet box with 0% and 0.5% ventilation. For this study, *Brassica oleracea* var. *capitata* L was shredded, packed in different packaging material then kept under refrigerator conditions at an interval of 5 days over a 25 days storage period. The physico-chemical analysis of Minimally Processed shredded cabbage with treatment T_5 having punnet box with 0% ventilation was preferred which revealed an increasing trend in PLW (0 to 1.99%) Titrable acidity (0.118-0.167%) and decreasing trend in TSS (4.36-4%), pH (5.74 to 5.67) and ascorbic acid content (42.50-38.07 mg/100 gm) for up to 25 days at refrigerator condition. It is evident from the present findings that all the parameters are significant with the advancement of storage period.

Keywords: Minimal processing, physio-chemical, TSS & packaging material

Introduction
Cabbage (*Brassica oleracea* var. *capitata* L. Family: Brassicaceae) is an important member of Cole crop having a chromosome No. 2 n = 2 x = 18 and its origin is Mediterranean region. The progenitor of cabbage is cole wart (*Brassica oleracea var. sylvestris*) with edible part as Head. The inflorescence of cabbage is called catkin. It is fifth largest vegetable crop of India with total production of 9.72 million metric tonnes from an area of 418 thousand hectares.
The head is nutritious and contains ascorbic acid (100 mg/100 g), protein (1.4%), carbohydrates (5.3%), fat (0.2%), calcium (0.73%), phosphorus (0.38%), potassium (2.71%), sulphur (1.16%) and water (92.4%). It is a rich source of vitamin C and vitamin K containing 44% and 72%, respectively of the daily value. Cabbage is also a moderate source of vitamin B6 and folate.
As soon as vegetables are harvested, they start to degrade. The perishability is ascribed to unfavourable physiological changes, such as biochemical starch hydrolysis, weight loss via respiration and transpiration, tissue softening, and a decrease in resistance to microbial attack. Vegetables which have little processing can be successfully stored by delaying the ripening process and biochemical reactions to lengthen their shelf life.
The storage life of cruciferous vegetables is found to be improved by the use of polyethylene bags and punnet boxs during packaging. The storage of minimally processed vegetables requires the use of correct packaging materials, which have many benefits such as protecting product quality, preventing pilferage during loading, transit, and market distribution, protecting against moisture loss, and boosting sales. Improvement in the existing methods of storage at Refrigerated conditions is essential. Improved packaging is crucial for maintaining both the quality and quantity of these products, which increases the marketability of minimally processed vegetable to the benefit of both customers and dealers (Vijay Sethi and Maini, 1989) [18]. Now a days, Polyethylene bags and punnet boxes are a popular type of consumer packaging for marketing of minimally processed vegetable for their beneficial effect. Therefore, the objective of the current study was to evaluate the physio-chemical properties of minimally processed shredded cabbage using multivariate statistical techniques, such as CRD.

Material and Methods

The present investigation is carried out in the Laboratory of Vegetable Science of Indira Gandhi Krishi Vishwavidyalaya Raipur (C.G.) during the year 2022-2023. The present study is "Effect of packaging material on physico-chemical properties of Minimally Processed shredded cabbage stored under refrigerator condition". A Minimally Processed shredded cabbage is designed in CRD (Completely Randomized Design) with 7 treatments and 3 replications. The treatment combinations of present investigation are given below in Table 1. For this investigation freshly harvested cabbage was collected from wholesale market, Raipur (C.G.).

Table 1: Treatment Details of the Experiment

Treatments	Treatments Details
T_1	200 Gauge + 0% ventilation
T_2	200 Gauge + 0.5% ventilation
T3	400 Gauge + 0% ventilation
T_4	400 Gauge + 0.5% ventilation
T_5	Punnet box + 0% ventilation
T_6	Punnet box + 0.5% ventilation
T_7	Control (Without packaging material)

Procurement of raw materials

Cabbages were collected from the wholesale market of Raipur (C.G)

Preparation of polyethylene bags

For cabbage polyethylene bags of 200 and 400 gauge measuring 10x7 inches were used. The three levels of ventilation i.e., no ventilation and 0.5% ventilation (14 holes or 7 punches) of 0.4cm diameter each were made on both the sides of the bags of all the gauges. A single punch machine was used to punch holes in the bags.

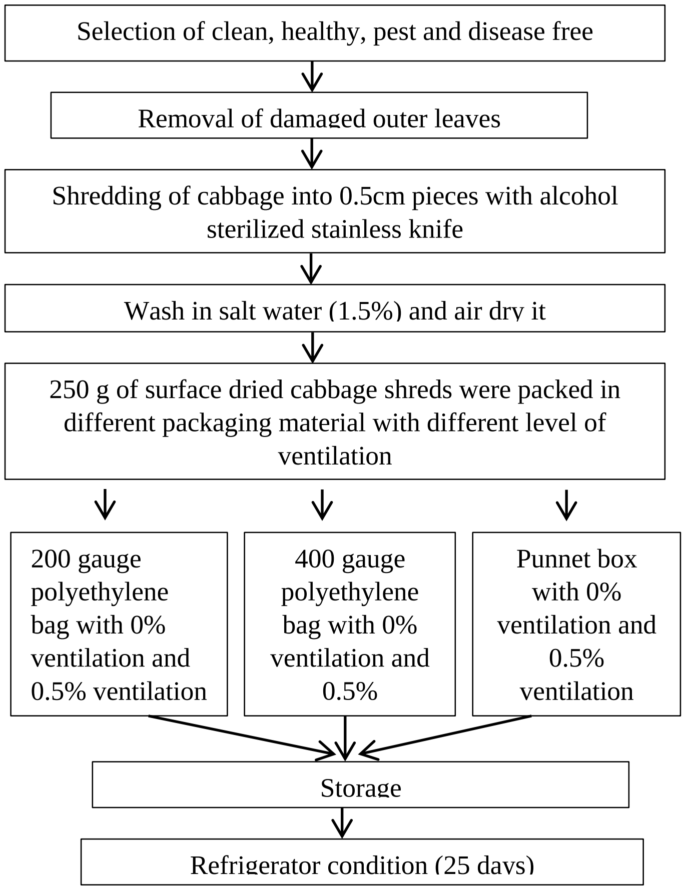
Calculations of ventilation

Area of the bags = 70 square inches or 177.1 sq cms.
Diameter of the hole = 0.4 cm
Area of each hole = Area of the circle = πr^2
(0.22) = 0.13 sq cm.
0.5% of 177.1 sq cm = 0.9 sq cm.
1 hole = 0.13 sq. cm =Holes to be punched to the cover
0.5% = 0.9 sq cm -0.9/0.13 = 6.92 = 7 punches

Preparation of cabbage for packaging.

In cabbage, clean, healthy and pest and disease free heads were selected. The damaged outer leaves were removed and shredded into 0.5 cm pieces with alcohol sterilized stainless knife and washed in salt water (1.5%) and air-dried.

The 250 g of surface dried cabbage shreds were packed in polyethylene bags according to the respective treatments and sealed using sealing machine. Before imposing the treatments, randomly selected cabbage shreds were used for recording the initial values of various parameters. In cabbage, clean, healthy and pest and disease free heads were selected. The damaged outer leaves were removed and shredded into 0.5 cm pieces with alcohol sterilized stainless knife and washed in salt water (1.5%) and air-dried. The 250 g of surface dried cabbage shreds were packed in polyethylene bags according to the respective treatments and sealed using sealing machine. Before imposing the treatments, randomly selected cabbage shreds were used for recording the initial values of various parameters.



Flow sheet for the preparation of minimally processed shredded cabbage

Observations recorded

Physiological loss in weight (PLW)

For determining Physiological loss in weight of minimally processed cabbage the packets were weighed every day on digital electronic balance for packets kept under ambient condition. Cumulative losses in weights were then calculated and results were expressed in percent physiological loss in weight using the following formula as given by Jagadeesh (1994) [11].

$$\%PLW = \frac{(\text{Initial wieght} - \text{Final weight})}{\text{Initial weight}} \times 100$$

Determination of pH

pH refers to the negative logarithm of hydrogen ion concentration.

$$pH = -\log(H^+)$$

pH was determined by using digital pH meter. The samples were taken individually in a beaker and pH meter was dipped into it and the readings were noted carefully.

Determination of Total soluble solids (TSS) %

TSS content of a product was determined by the index of refraction. It is measured by using hand refractometer, and also referred as degrees Brix. It tests the solids concentration of a sucrose containing solution. A few drops of sample were placed on hand refractometer and total soluble solids were recorded on the scale of the instrument and it is expressed in percent (%).

Acidity (%)

5 ml sample was taken and dissolved in 50 ml of distilled water and from this 20 ml aliquot was taken out and titrated with 0.1 N NaoH using few drops of phenolphthalein as indicator. End point was judged by the appearance of pink colour. The acidity of the juice is expressed in terms of percent acidity. Acidity was calculated by finding out titre value with the help of following formula.

$$\text{Acidity(\%)} = \frac{\text{Titre value} \times \text{Normality} \times \text{Eq.wt.of acid} \times \text{volume made up} \times 100}{\text{Weight of sample taken} \times \text{sample taken for estimation} \times 1000}$$

Determination of ascorbic Acid (mg/100 g)

Reagents

Metaphosphoric acid (HPOʒ) solution (3%)

For the preparation of 3 percent metaphosphoric solution 30 gm of metaphosphoric acid sticks was diluted in 1 litre of distilled water.

Dye solution

50 mg of 2,6-dichlorophenol-indophenol was dissolved in about 150 ml of hot distilled water, containing 42 mg of Sodium bicarbonate and was cooled and diluted to 200 ml with distilled water, solution was stored in a brown bottle in a refrigerator at 3 °C and standardize every day.

Standard ascorbic acid solution

100 mg of L-ascorbic acid was weighted properly and dissolved in a small amount of 3 percent metaphosphoric acid and volume make up to 100ml with the same solution. 10 ml of this stock solution was diluted to 100 ml with 3 percent metaphosphoric acid (0.1 mg ascorbic acid/ml).

Standardization of dye

5ml of standard ascorbic acid solution and 3 percent metaphosphoric acid each was taken in a volumetric flask and was titrated with dye solution filled in the micropipette, until pink colour persists for 10 seconds. Dye factor was calculated (mg of ascorbic acid/ ml of dye) as follow.

$$\text{Dye factor} = \frac{0.5}{\text{Titre value}}$$

Sample preparation and titration

10 ml of sample was taken and make upto 100 ml with 3 percent metaphosphoric acid and filtered. 10 ml of filtrate was pipet out into a conical flask and was titrated with standard dye till pink red end point appears.

$$\text{Ascorbic Acid (mg/100g)} = \frac{\text{Titre} \times \text{Dye factor} \times \text{Volume made up} \times 100}{\text{Volume of filtrate taken} \times \text{Volume of sample taken}}$$

Results and Discussion

Physiological weight loss

The findings (Table 2) of the data showed that the effect of different treatment combinations on weight loss content of minimally processed shredded cabbage during storage period was found significant on all day of storage period.

The weight loss value at 5th day of storage was recorded maximum for T_7 having 35.71% followed by T_2 and T_4 was having weight loss 0.764% and 0.214% respectively. While there is no weight loss in T_1, T_3 and T_5.

The weight loss value at 10th day of storage was recorded maximum for T_7 having 54.63% followed by T_2 and T_4 was having weight loss 1.467% and 0.394% respectively. While the minimum weight loss of 0.158% was noted in treatment T_5 followed by T_3 (0.264%) The weight loss value at 15th day of storage was recorded maximum for T_2 having 1.995% followed by T_1 and T_4 has weight loss 0.679% and 0.623% respectively. While the minimum weight loss of 0.349% was noted in treatment T_5 followed by T_3 (0.480%).

The weight loss value at 20th day of storage was recorded maximum for T_2 having 3.059% followed by T_4 and T_6 has weight loss 0.895% and 0.840% respectively. While the minimum weight loss of 0.541% was noted in treatment T_5 followed by T_3 (0.695%).

The weight loss value at 25th day of storage was recorded maximum for T_2 having 4.946% followed by T_4 and T_1 has weight loss 1.269% and 1.207% respectively. While the minimum weight loss of (0.12%) was noted in treatment T_5 followed by T_3 (0.21%).

From the observation, it was discovered that throughout the course of the 25th day of storage, the weight loss content of the minimally processed shredded cabbage greatly increases. T_2 likewise recorded maximum weight loss, which increased from 0.764% to 4.946%, and T_5 reported minimum weight loss, which increased from 0 to 1.99% over the course of storage. The weight loss content of T_7 remained at its highest up to the 10th day and increased from 31.713% to 54.630%.

It is clear from the previous result that T_5 was the treatment with the least variation in weight loss, indicating that it was the most stable treatment among those who used a punnet box with 0% ventilation. T_7 however, exhibits the greatest alteration over storage.

The packaging of minimally processed cabbage in polyethylene bags without ventilation and storing them in refrigerated condition delayed the loss of PLW, which may be due to modified atmosphere created in the package. It is evident that the rate of physiological and biochemical changes in minimally processed cabbage during storage are dependent on temperature and relative humidity. Hence slower the rate of these changes in minimally processed cabbage in refrigerated storage might be due to low temperature and relative humidity maintained in refrigerated storage. Under low temperature and high relative humidity in the refrigerated storage, the rate of respiration and enzymatic activities were probably at a slow rate thereby delaying the senescence. This finding is in conformity with the findings of other worker who have found delay in PLW and extension of storage life of broccoli (Forney *et al*., 1989) [8].

Low temperature is best storage treatment for retarding all physiological and pathological deterioration. Low temperature reduces respiration and other metabolic activities (Faraglier *et al*., 1984a) [6], transpiration (Faragher *et al*., 1984b) and fungal growth (Hardenburg *et al*., 1986) [7].

pH

The analysis of pH values from minimally processed shredded cabbage is reported in (Table 3). It was found that pH content of minimally processed shredded cabbage during storage period was significant on all day of storage period.

T_1 had the highest pH value of 5.91 on the 5th day of storage. In treatment T_6, minimum pH of 5.73 was observed. T_1 had the highest pH value of 5.89 on the 10th day of storage, followed by T_7 with a pH of 5.85. While treatment T_6 had a minimum pH of 5.71.

Table 2: Changes in Weight Loss (%) of Minimally Processed Shredded Cabbage stored in refrigerator condition.

Treatment	Weight Loss (%)				
	5th day	10th day	15th day	20th day	25th day
T_1 (200 Gauge + 0% ventilation)	0000	0.403	0.679	0.809	1.207
T_2 (200 Gauge + 0.5% ventilation)	0.764	1.467	1.995	3.059	4.946
T_3 (400 Gauge + 0% ventilation)	0000	0.264	0.480	0.695	0.854
T_4 (400 Gauge + 0.5% ventilation)	0.214	0.391	0.623	0.895	1.269
T_5 (Punnet box + 0% ventilation)	0000	0.158	0.349	0.541	0.749
T_6 (Punnet box + 0.5% ventilation)	0.136	0.344	0.602	0.840	1.199
T_7 (control)	35.713	54.63	0000	0000	0000
Mean	5.261	8.237	0.675	0.977	1.461
SE(m)±	0.726	0.401	0.073	0.075	0.108
CD at 5%	7.889	2.784	6.200	4.401	4.257
CV (%)	0.239	0.132	0.024	0.025	0.036

After 10 days of storage, the T_7 (control) treatment became deteriorated. So pH was determined for all other treatments except T_7, with T_1 having the highest value of 5.88. T_6 had the lowest pH of 5.69, followed by T_5 (5.70).

The pH value during the 20th day of storage was highest for T_2, with 5.86, followed by T_3 (5.77), and lowest for T_6, with 5.67, followed by T_5 (5.69). T_1 had the highest pH value of 5.85 on the 25th day of storage, whereas treatment T_6 had the lowest pH of 5.68, followed by T_5 (5.67).

From the above observation it was found that the pH content of the minimally processed shredded cabbage decreases significantly over storage due to the increased microbial growth and greater stress caused due to higher intensity of cut might have resulted in larger production of acids. The pH value of T_1 remains maximum during all the storage days and decreased from 5.91 to 5.85 over a storage period and minimum pH value was recorded for T_6 which decreased from 5.73 to 5.68 for 5th day to 25th day.

Greater stress caused by higher intensity of cut may have resulted in larger production of acids, and consequently, an increase in acidity and slow reduction in pH content of fresh cut purple onion, as reported by Berno *et al.* (2014) [2]. This steady fall in pH with a relatively modest increase in acidity could be attributed to increased microbial growth in little processed products, which produces organic acids during storage regardless of packaging material or ventilation under consideration. According to Silva *et al.* (2009) [16] the steady fall in pH with the relatively modest increase in acidity may be attributed to higher microbial growth in less processed products, which produces organic acids during storage regardless of coating treatments.

Table 3: Changes in pH of Minimally Processed Shredded Cabbage stored in refrigerator condition

Treatment	pH				
	5th day	10th day	15th day	20th day	25th day
T_1(200 Gauge + 0% ventilation)	5.91	5.89	5.88	5.86	5.85
T_2 (200 Gauge + 0.5% ventilation)	5.81	5.78	5.77	5.75	5.74
T_3 (400 Gauge + 0% ventilation)	5.82	5.81	5.79	5.77	5.77
T_4 (400 Gauge + 0.5% ventilation)	5.80	5.78	5.76	5.75	5.73
T_5 (Punnet box + 0% ventilation)	5.74	5.72	5.70	5.69	5.67
T_6 (Punnet box + 0.5% ventilation)	5.73	5.71	5.69	5.67	5.68
T_7 (control)	5.87	5.85	000	000	000
Mean	5.81	5.79	4.94	4.92	4.91
SE(m)±	0.009	0.010	0.009	0.009	0.568
CD at 5%	0. 030	0. 031	0. 027	0. 028	1.725
CV (%)	0.295	0.303	0.315	0.331	2.506

Total soluble solids (TSS)

Changes on TSS content of minimally processed shredded cabbage having seven treatments were recorded at 5th day, 10th day, 15th day, 20th day and 25th day of the storage period. The perusal of data pertaining to TSS of minimally processed shredded cabbage has been presented in (Table 4) and graphically depicted in (Figure 1).

The evaluation of the data showed that the effect of different treatment combinations on TSS content of minimally processed shredded cabbage during storage period was found significant on all day of storage period.

The TSS value at 5th day of storage was recorded maximum for T_7 having (5.6%) followed by T_1 and T_3 having TSS (4.66%) and (4.53%) respectively. While the minimum TSS of (4.36%) was noted in treatment T_6 followed by T_4 (4.43%) and T_5 (4.43%).

The TSS value at 10th day of storage was recorded maximum for T_7 having (5.0%) followed by T_1 and T_2 having TSS (4.53%) and (4.36%) respectively. While the minimum TSS of (4.36%) recorded for T_4 and T_6 followed by T_5 (4.30%).

Treatment T_7 (control) was lost only up to 10 days of storage period. So TSS was examined for all other treatments except T_7, out of other treatment T_1 (4.30%) having the highest TSS While treatment T_6 had a minimum TSS of 4.10%. Additionally, it is noted that T_1 had 4.30% of its maximum on day 20th of storage. While treatment T6 had a minimum TSS of 4.03%. And on 25th day it was recorded maximum for T_1 having 4.20%. While the minimum TSS of 4.00% was noted in treatment T_6.

From the above observation it was found that the TSS content of the minimally processed shredded cabbage decreased significantly over storage period. Due to cell structural damage from the shredding process and enzyme and substrate compartmentalization that alters TSS and flavour, the minimally processed shredded cabbage's TSS level substantially dropped. The TSS content of T_7 remains maximum up to 10 days of storage i.e., 5.6% to 5.0% and from 10th day to 25th day TSS was recorded maximum for T_1 (4.66% to 4.20%) and minimum TSS was recorded for T6 (4.36% to 4%) over a storage period.

From the above observation minimum change in TSS was observed for T_5 which implies that it is the most stable treatment among all the other treatment having treatment combination of punnet box with 0% ventilation.

A decrease in TSS content of fresh cut onion over a period of time might be attributed to the damage caused in the cell structure by the cutting process, thus causing part of its content to be eliminated as reported by Berno *et al*. (2014) [2] and DE compartmentalization of enzymes and substrates altering TSS and flavor as reported by Blanchard *et al*. (1996) [3], Rico *et al*. (2007) [15] and Hodges and Toivonen (2008) [10] in fresh cut vegetables. Also, utilization of soluble solids as a source of energy reserves over time could be another reason for the reduction in TSS. The maximum decrease in TSS was recorded, this might be due to the increased intensity of cut as reported by Toivonen and DeEll (2002) [17] in fresh cut vegetables and Baskaran *et al*. (2015) [1]. The probable reduction in TSS content might be due to the minimal processing that when injuring the fruit promoted greater sugar degradation i.e. being used as a substrate in the respiratory metabolism since the transpiration rate was higher in minimally processed and vacuum packed products (Silva *et al*., 2009) [1].

Table 4: Changes in TSS (%) of Minimally Processed Shredded Cabbage stored in refrigerator condition

Treatment	TSS				
	5th day	10th day	15th day	20th day	25th day
T_1 (200 Gauge + 0% ventilation)	4.66	4.53	4.36	4.30	4.20
T_2 (200 Gauge + 0.5% ventilation)	4.50	4.36	4.33	4.23	4.13
T_3 (400 Gauge + 0% ventilation)	4.53	4.33	4.23	4.13	4.00
T_4 (400 Gauge + 0.5% ventilation)	4.43	4.23	4.13	3.96	3.90
T_5 (Punnet box + 0% ventilation)	4.43	4.30	4.16	4.10	4.00
T_6 (Punnet box + 0.5% ventilation)	4.36	4.23	4.10	4.03	4.00
T_7 (control)	5.60	5.00	0000	0000	0000
Mean	4.647	4.428	3.619	3.538	3.4619
SE(m)±	0.348	0.216	0.157	0.101	0.06889
CD at 5%	4.277	2.787	2.486	1.631	1.13636
CV (%)	0.114	0.071	0.052	0.033	0.02271

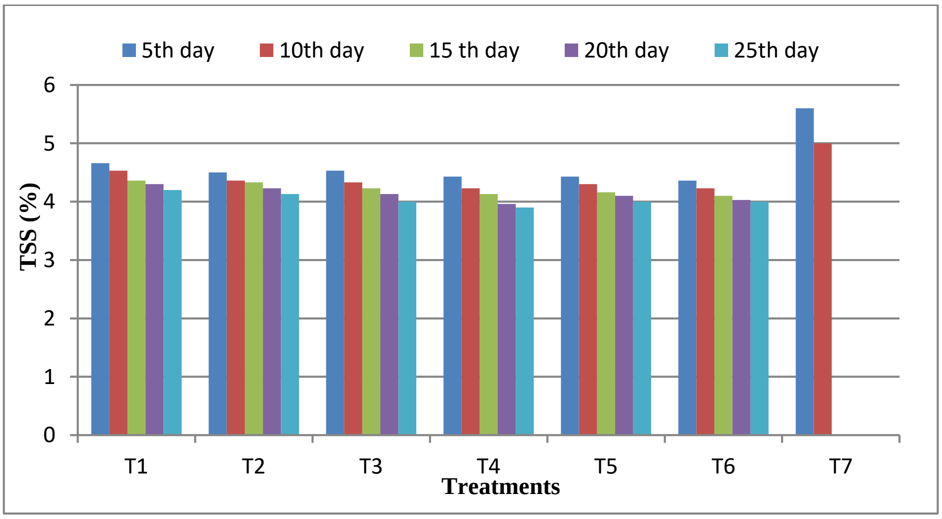


Fig 1: Changes in TSS of Minimally Processed Shredded Cabbage stored in refrigerator condition

Titrable acidity

The Acidity of minimally processed shredded cabbage has been presented in (Table 5) and graphically depicted in (Figure 2). The critical evaluation of the data showed that the effect of different treatment combinations was found significant on all day of storage period.

The Acidity value at 5th day of storage was recorded maximum for T_7 having 0.256% followed by T_1 and T_2 has Acidity 0.200% and 0.189% respectively. While the minimum Acidity of 0.118% was noted in treatment T_6 followed by T_5 (0.134%).

The Acidity value at 10th day of storage was recorded maximum for T_7 having (0.290%) followed by T_1 and T_2 having acidity 0.211% and 0.200% respectively. While the minimum Acidity of 0.124% was noted in treatment T6 followed by T_5 (0.145%).

T_7 (control) treatment was edible up to 10 days of storage after that it became inedible. So TSS was examined for all other treatments except T_7, out of other treatment it is recorded maximum for T1 having 0.234% followed by T_2 and T_3 has Acidity 0.211% and 0.189% respectively. While the minimum Acidity of 0.129% was noted in treatment T_6 followed by T_5 (0.156%) The Acidity value at 20th day of storage was recorded maximum for T_1 having 0.256% followed by T_2 and T_3 has Acidity 0.245% and 0.201% respectively. While the minimum Acidity of 0.145% was noted in treatment T_6 followed by T_5 (0.178%).

The Acidity value at 25th day of storage was recorded maximum for T_1 having 0.279% followed by T_2 and T_3 has Acidity 0.267% and 0.223% respectively. While the minimum Acidity of 0.167% was noted in treatment T6 followed by T_5 (0.189%) According to the findings, the acidity level of the

minimally processed shredded cabbage increased significantly up to the 25th day of storage. TSS level of T_7 remained highest on the 5th and 10th days, while acidity was highest for T1 (0.200% to 0.279%) and lowest for T_6 (0.118% to 0.167%) from the 10th to the 25th day of storage.
It is obvious from the above observation that T_6 had the smallest change in acidity, implying that it is the most stable treatment among all the other treatments with the treatment combination of punnet box with 0.5% ventilation.
Piga *et al*. (2000) [14] found that minimally processed product stored at 15 ºC showed a significant fall in pH value and a fast increase in titratable acidity beginning on day 4 of storage. Lamikanra *et al*. (2000) [12] investigated the physio- chemical changes in minimally processed product held at 4 °C and 20 °C, including pH, titratable acidity, °Brix, organic acids, sugars and amino acids. Most biochemical parameters changed only gradually over the course of storage at the reduced temperature. At this temperature, the formation of lactic acid led to a significant increase in organic acid concentration over time.

Table 5: Changes in Titrable acidity (%) of Minimally Processed Shredded Cabbage stored in refrigerator condition

Treatment	Titrable acidity (%)				
	5th day	10th day	15th day	20th day	25th day
T_1 (200 Gauge + 0% ventilation)	0.200	0.211	0.234	0.256	0.279
T_2 (200 Gauge + 0.5% ventilation)	0.189	0.200	0.211	0.245	0.267
T_3 (400 Gauge + 0% ventilation)	0.156	0.178	0.189	0.201	0.223
T_4 (400 Gauge + 0.5% ventilation)	0.145	0.156	0.178	0.189	0.212
T_5 (Punnet box + 0% ventilation)	0.134	0.145	0.156	0.178	0.189
T_6 (Punnet box + 0.5% ventilation)	0.118	0.124	0.129	0.145	0.167
T_7 (control)	0.256	0.290	0000	0000	0000
Mean	0.200	0.186	0.156	0.173	0.191
SE(m)±	0.0355	0.0480	0.0340	0.0363	0.0337
CD at 5%	11.856	14.7056	12.4058	11.9509	10.0738
CV (%)	0.0117	0.0158	0.0112	0.0119	0.0111

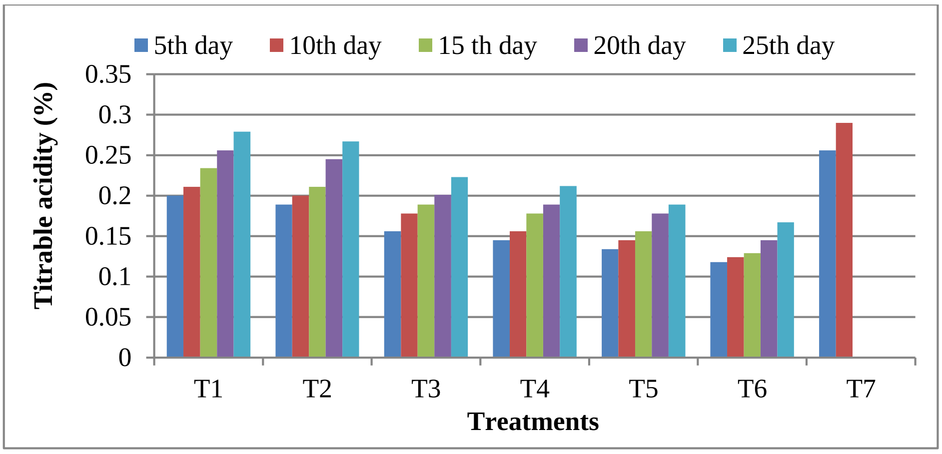


Fig 2: Changes in Titrable acidity (%) of Minimally Processed Shredded Cabbage stored in refrigerator condition

Ascorbic acid

Critical analysis of the results revealed that all days of the storage period were relevant for the impact of various treatment combinations on the ascorbic acid content of minimally processed shredded cabbage. Table 6 and Figure 3 both provide data on ascorbic acid levels in minimally processed shredded cabbage.
The ascorbic acid value at 5th day of storage was recorded maximum for T_5 42.50 mg/100 g followed by T_6 and T_3 having ascorbic acid 41.66 mg/100 g and 40.00 mg/100 g respectively. While the minimum ascorbic acid content of 35.41 mg/100 g was noted in treatment T_7 followed by T_2 (37.58 mg/100 g). On 10th day of storage it was recorded maximum for T_5 having 41.48 mg/100 g followed by T_6 and T_3 having ascorbic acid 40.73 mg/100 g and 39.21 mg/100 g respectively and minimum ascorbic acid of 33.33 mg/100 g was noted in treatment T_7 followed by T_2 (36.57 mg/100 g). At 15th day of storage it was recorded maximum for T_5 having 40.62 mg/100 g followed by T_6 and T_3 was having ascorbic acid 39.58 mg/100 g and 38.19 mg/100 g respectively and lowest ascorbic acid of 35.75 mg/100 g was noted in treatment T_2. Ascorbic acid value at 20th day of storage was recorded maximum for T_5 having 39.43 mg/100 g followed by T_6 and T_3 was having ascorbic acid 38.47 mg/100 g and 37.17 mg/100 g respectively and minimum ascorbic acid of 34.60 mg/100 g was noted in treatment T_2.
Ascorbic acid value at 25th day of storage was recorded maximum for T_5 having 38.07 mg/100 g followed by T_6 and T_3 has 37.31 mg/100 g and 36.20 mg/100 g respectively and minimum of 33.61 mg/100 g was noted in treatment T_2.
From the above-mentioned observation, it was discovered that up until the 25th day of storage, the ascorbic acid concentration of the minimally processed shredded cabbage dramatically reduced. The largest ascorbic acid concentration was found in T^5, which declined from 42.50 mg/100 g to 38.07 mg/100 g over the course of the storage period. The lowest ascorbic acid concentration was found in T_2, which decreased from 37.58 mg/100 g to 33.61 mg/100 g up until the 25th day of storage.
It is evident from the above result that T_3 observed the least

variation in ascorbic acid, indicating that it is the most stable therapy out of all the treatments because it uses 400 gauge polyethylene bag with no ventilation.

Refrigerated storage significantly maintained higher ascorbic acid content, which may be due to low storage temperature that might have been assisted in the preservation of ascorbic acid content. The same results were also reported in Jalapeno pepper rings.

Minimally processed cabbage packed in polyethylene bags significantly reduced the loss of ascorbic acid compare to non- packed ones. This may be due to the effect of polyethylene bags that reduce oxidation of ascorbic acid compared to non-packed minimally processed. Maintenance of atmospheric composition and greater humidity inside the packages helps in greater retention of ascorbic acid content. Similar results were also obtained by Ezell and Wilcox (1954) [5] and Barth *et al*. (1993) [4].

Minimally processed cabbage packed in punnet box with 0% ventilation retained the higher ascorbic acid content than other packaging material with different level of ventilation. This may be due to ventilated polyethylene bags have accelerated more oxidation of ascorbic acid which leads to decrease in ascorbic acid content. Polyethylene bags with no ventilation contain lower oxygen, high carbon dioxide and greater humidity inside the bags reduced the degradation of ascorbic acid content. This is in conformity with the results obtained in Broccoli spears (Barth *et al*., 1993) [4].

Table 6: Changes in Ascorbic acid (mg/100 g) of Minimally Processed Shredded Cabbage stored in refrigerator condition

	Ascorbic acid (mg/100 g)				
	5th day	**10th day**	**15th day**	**20th day**	**25th day**
T_1 (200 Gauge + 0% ventilation)	38.33	37.03	36.10	35.25	34.20
T_2 (200 Gauge + 0.5% ventilation)	37.58	36.57	35.75	34.60	33.61
T_3 (400 Gauge + 0% ventilation)	40.00	39.21	38.19	37.17	36.20
T_4 (400 Gauge + 0.5% ventilation)	39.58	38.51	37.15	36.21	35.13
T_5 (Punnet box + 0% ventilation)	42.50	41.48	40.62	39.43	38.07
T_6 (Punnet box + 0.5% ventilation)	41.66	40.73	39.58	38.47	37.31
T_7 (control)	35.41	33.33	0000	0000	0000
Mean	39.29	38.12	32.48	31.59	30.64
SE(m)±	1.725	1.724	1.430	1.413	1.107
CD at 5%	2.5065	2.5827	2.5123	2.5535	2.0622
CV (%)	0.569	0.568	0.471	0.466	0.365

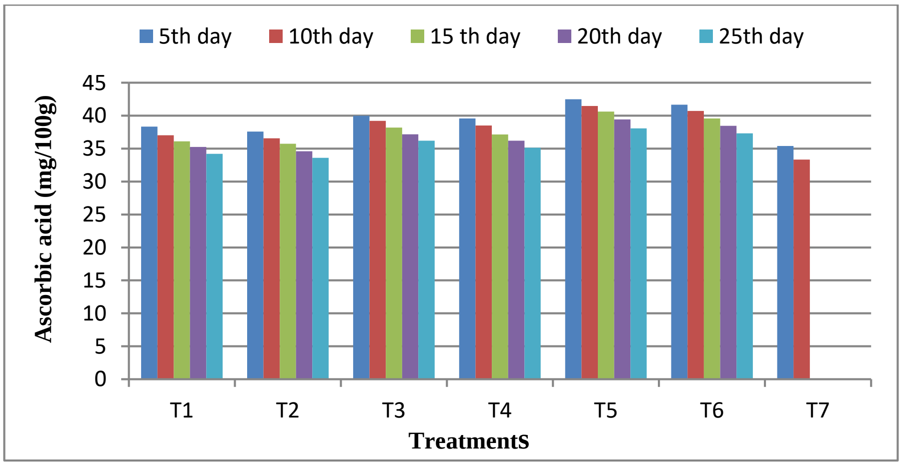


Fig 3: Changes in Ascorbic acid (mg/100 g) of Minimally Processed Shredded Cabbage stored in refrigerator condition

Conclusion

This research emphasizes to study effect of packaging material on physico- chemical properties of Minimally Processed shredded cabbage stored under refrigerator condition. Three different packaging materials were used with 0% and 0.5% ventilation. Throughout the storage period it was observed T_7 (control) recorded increase in PWL, acidity content and decrease in pH content, TSS content and ascorbic acid up to 10 days of storage period after that it was discarded. Among other treatments T_2 having maximum loss increased from (0.764 to 4.946%) and minimum loss observed in T_5 increased from (0 to 1.99%). TSS of T_1 having maximum TSS content decreased from (4.66% to 4.20%,) and having minimum was observed in T_6 which decreased from (4.13% to 3.43%), pH for T_1 noted maximum pH content which decreased from (5.91 to 5.85) and T_6 having minimum pH decreased from (5.73 to 5.68), acidity for T_1 was noted highest which increased from (0.200% to 0.279%) and minimum was observed in T6 which decrease from (0.118% to 0.167%), ascorbic acid content was recorded highest for T_5 decreased from (42.50 to 38.07 mg/100 g) and minimum was noted on T_2 which decreased from (37.58 to 33.61 mg/100 g). From this investigation it is also clear that PWL and acidity increased and pH, TSS and ascorbic acid decreases over 25 days of storage period.

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