Shelf Life Study of Minimally Processed Carrot through Modified Atmospheric Packaging

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Abstract

Owing to the convenience of fresh cut fruits and vegetable, the demand for ready to eat fresh cut fruits and vegetable has grown exponential increase in the market. However fresh cut produce cannot be kept for longer period due to serve stress exerted on the cut surface resulting in faster deterioration. In order to meet the rising demand of the consumers, various techniques have been developed among which modified atmospheric packaging along with low temperature storage are being increasingly employed to extend the shelf life of the produce and also to be maintain the quality. In the present study effort were undertaken to prepare minimally processed sliced carrot and stored those minimally processed carrot slices under different perforated and non-perforated packaging material of polypropylene (PP) and low density polyethylene (LDPE) at both ambient and low temperature (4^0C) storage. The carrot slices thus stored was analysed for its physico-chemical parameters after every 7 days of interval till 35 days of storage period. The value obtained were statistical analysed using ANOVA at probability level of ($P \geq 0.05$) to draw any significance difference among various type of treatment combination. Result shows that minimally processed carrot can be kept satisfactorily for 14 days in case of ambient temperature storage and up to 35 days in case of storage at low temperature (4^0C) in both the perforated and non-perforated packaging material of LDPE and PP. increase in weight loss, reducing sugar with considerable decrease in TSS, pigment content and sugar content were observed in all stored packs more under ambient condition as compared to low temperature storage. Among the packaging material, non perforated packaging material of LDPE and serve best regarding the reduction of weight loss, pigment retention and sugar retention but while considering the TSS, reducing sugar and L* value the perforated packaging material of PP at low temperature storage serve the best packaging material.

***Keywords**: Minimally processed carrot, Packaging, Perforation, Storage, Shelf Life, Quality*

1. Introduction

The recent trend for fresh cut produce industry is showing exponential increase demand in many countries, especially in large metropolitan cities in both fruits (54%) and vegetable (46%) (**Rojo & Saabor, 2002**). The fresh cut produce focuses on the freshness, convenience and it's spurred by heath attributes attached to it. Minimal processing (fresh cut) comprises selection, washing, peeling and cutting **(Cantwell, 2000; Kluge et *al.* 2010)** producers that are aimed at producing a product that is fresh and convenient to prepare and consume **(Burns, 1995).** In general, fresh cut product a short shelf life, which is mainly due to the mechanical stresses. In the cut surface, cell and membrane are damaged leading to alteration in the whole tissue metabolism.

Among vegetables, carrots are now increasingly consumed, mainly due to their pleasant flavor and perceived health benefits related to their vitamins, minerals and dietary fiber (**Alasalvar et al., (2001); Holland, Welch et al., (1995).** Carrots have been ranked tenth in terms of their nutritional value among 38 other fruits and vegetables, and seventh for their contribution to nutrition

(US Agricultural Statistics, 1971). However, little is known about the antioxidant activity and phytonutrients in either orange or purple carrots. Bright orange contain two important phytochemicals: Carotenoids and flavonoids, which are natural bioactive compounds. These phytochemicals work with nutrients and dietary fiber to protect people against disease. Beta-carotene, a member of the Carotenoids family, protects the body by decreasing the risk of heart diseases, stroke, blindness and certain type of cancer. **(Bureau of Agriculture statistics, BAS, 2006).**

Various techniques have been developed to extend the shelf life of minimally processed product. A more recent and successful technique regarding the extension of quality and shelf life of minimally processed product is the adoption of modified atmosphere packaging and cold storage by minimizing stress reactions **(Huxsoll *et al*., 1989; Kader *et al*., 1989; Labuza and Breene, 1989; Bolin and Huxsoll, 1991).** Modified atmospheric packaging involves the use of polymeric films with specific permeability to O_2, CO_2 and water vapour. Depletion of O_2 and elevation of CO_2 can be achieved passively depending on the respiration of the vegetables material and permeability of the packaging film or actively by flushing a desired mixture of gases into the package **(Zagory and Kader, 1988, Ballantyne *et al*., 1988)** resulting in changes in the initial atmospheric composition due to physiological activity of the product as well as characteristics of the physical environment **(Gorris and Peppelenbos, 1992).** A primary effect of vegetable packaging under modified atmospheres is the reduction of both O_2 consumption and CO_2 production. Therefore, the respiration rate decreases, metabolism becomes slower, ripening is delayed, microbial spoilage is reduced and chlorophyll degradation is decreased **(Day, 1989; Solomos, 1995).**

In view of the above facts and increasing economic importance of carrot in fresh cut produce industry, the study was undertaken with the objective of determining the effect of different packaging materials and storage temperatures on quality parameters of minimally processed carrot stored in modified atmospheric packaging**.**

2. Materials and Method

Fresh carrot ("*Daucus carota* L") was procured from a local market (Sabji mandi, Allahabad) in the region of Uttar Pradesh. The carrot previously selected for firmness, absence of mechanical damage and fungal infection, and subsequently prewashed in cold water and placed in cold room at 10^0C for later processing.

2.1 Minimally Processed Carrot

The carrot were manually sliced into 5 mm thick discs. Stainless steel knives were used for slicing. After slicing the material has been sanitized for 5 minutes in Potassium Metabisulphate solution , KMS (2000 ppm) in order to reduce the risk of microbiological contamination.
They were left to drip-dry for 5 minutes in a perforated cage. For the removal of excess water, fresh cut beets were placed and wrapped inside the blotting paper for 30 seconds. Minimally processed beet roots were then weighed (100 g) and packaged into two types of packaging film i.e., LDPE and PP in six replications. The packages were then heat sealed immediately after filling with a pedal operated heat sealer. Half of each type of the sealed film was given a pin-hole perforation and a replication of three was made for the resulting four types. Finally, the sealed packages were stored both at ambient and at low room (4°C) temperature with a relative humidity varying from 80-90 %. The storage period was 35 days and 3 replications from each treatment were analyzed after every 7 days from the day of processing.

2.2 Storage

Finally, the sealed packages were stored both at ambient and at cold room (4°C) temperature with a relative humidity varying from 80-90% for analysis after every 7 days of storage. Thus eight treatment (sliced carrot packed in LDPE and stored at ambient temperature-**LDPE $_{A\ \&\ NP}$,** sliced carrot packed in perforated LDPE and stored at ambient temperature – **LDPE $_{A\ \&\ P}$,** sliced carrot packed in LDPE and stored at 4^0C cold room temperature – **LDPE $_{Low\ \&\ NP}$,** sliced carrot packed in perforated LDPE and stored at 4^0C cold room temperature – **LDPE $_{Low\ \&\ P}$,** sliced carrot packed in PP and stored at ambient temperature – **PP $_{A\ \&\ NP}$,** sliced carrot packed in perforated PP and stored at ambient temperature – **PP $_{A\ \&\ P}$,** sliced carrot packed in PP and stored at 4^0C cold room temperature – **PP $_{Low\ \&\ NP}$,** sliced carrot packed in perforated PP and stored at 4^0C cold room temperature – **PP $_{Low\ \&\ P}$)** were experiment in this study. The storage period was 35 days and 3 replication from each treatment were analyzed after every 7 days from the day of processing. Both physical and chemical analyzed were carried out to determine the various parameters; Under physical analysis were weight loss, TSS (Total Soluble Solid), colour and organoleptic properties were determined and in chemical analysis beta-carotene amount, reducing sugar and total sugar were determined.

3. Physico-chemical analysis

The variables analyzed were :
3.1weight loss: determined by weighing the individual bag on the day of observation using a laboratory level electronic weighing balance.

3.2TSS: one or two drops of the juice were placed on the Refractometer plate (PAL-1, Atago, Japan) and the percent TSS on the scale were recorded.

3.3 Colour: carried out using a Hunter Colorimeter (Hunter Associates Labs, Reston, VA, USA) on the basis of 3 variables (L*, a*, b*). The instrument was calibrated against a standard black as well as white reference tiles. Readings were made by direct applying the chromameter head onto the surface of minimally processed products. Pigmentation differences were compensated by reporting averages of 4 readings.

3.4 Organoleptic properties: Product quality was judged at room temperature by an informal panel of ten people (all members of Sam Higginbottom institute Agriculture, Technology and Sciences, Allahabad). Fresh beet from the batch used for processing were used as the control (score 9). Sliced beet root were assessed for colour intensity, appearance, odour intensity, presence or absence of fungi, texture and general acceptance using a nine point hedonic rating scale **(Lawless & Heymann, 1998).** The entire experiments were repeated 3 times and mean score for overall acceptance was calculated and score above 5 indicated unacceptable samples.

3.5 Beta-carotene content

5g of fresh sample was taken in 10 to 15 ml of acetone, and few crystal of anhydrous sodium sulphate was added. The supernant was decanted in a beaker. The process was repeated twice and supernatant was transferred into a separators funnel. After that 10-15 mL of petroleum ether was added and mixed thoroughly, two layers were separated out on standing. The lower layer was discarded and the upper layer was collected in a 100 mL of volumetric flask, and volume was made up to 100 mL with petroleum ether and optical density at 452 nm using petroleum ether as blank was recorded.

Calculation

$$\mu g \text{ of Betacarotene per } 100\ g = \frac{\mu g \text{ of carotene per mL as read from the curve } X \text{ Dilution } X\ 100}{\text{Weight of the sample } X\ 1000}$$

Reducing sugar and total sugar: estimated by using the Shaffer-Somogyi micro method (**Rangana, 2005).**

Calculation

$$\% \text{ Reducing sugar} = \frac{\text{mg of Dextrose } X \text{ Volume made up } X100}{5\ X \text{ Weight of the sample taken } X\ 1000}$$

$$\% \text{ Total sugar as invert sugar} = \frac{\text{mg of Dextrose } X \text{ Volume made up } X100}{\text{Titre } X \text{ Weight of the sample taken } X\ 100}$$

3.6Statistical analysis: All the experiments were conducted in triplicate and the average values were computed. Data were subjected to Analysis of Variance (ANOVA) to evaluate the significant difference at probability level of ($P \geq 0.05$) using the software STATISTICA 6.0.

4. Results and Discussion

4.1 Weight loss: The maximum weight loss on 35th day was observed in samples stored at room temperature with and without perforations. The maximum retention of moisture was found in samples stored at low temperature (4°C) in non perforated packaging materials of PP and LDPE followed by perforated packaging materials of PP and LDPE. The loss of weight may be due to enhancement of the respiration rate after shredding and slicing activities where fruits no longer remain intake. Statistically there was no significant difference in weight loss for all treatment combinations.

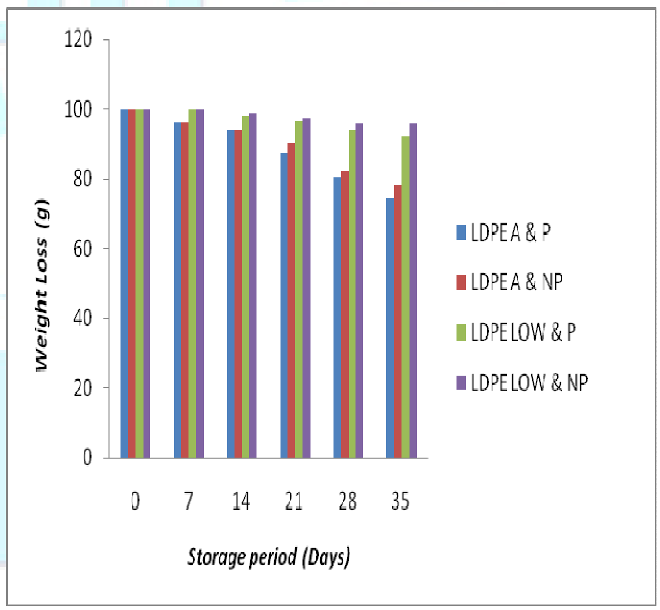

Fig.4.1. Effect of storage temperature, perforated and non-perforated LDPE packaging, material on weight loss of minimally processed carrot.

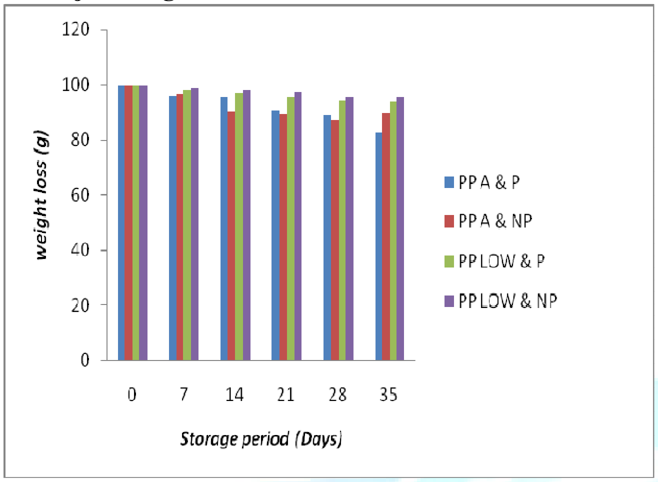

Fig.4.2. Effect of storage temperature, perforated and non-perforated PP packaging, material on weight loss of minimally processed carrot.

4.2 TSS: There is an overall decrease in TSS in all the treatments during the storage period. It has been further observed that the decrease in TSS was significant in initial seven days of storage. Little variation in TSS level was observed during storage. PP at low temperature in perforated packaging has shown maximum TSS on 35th day of storage. The minimum TSS on 35th day was observed in samples stored at room temperature with and without perforations.

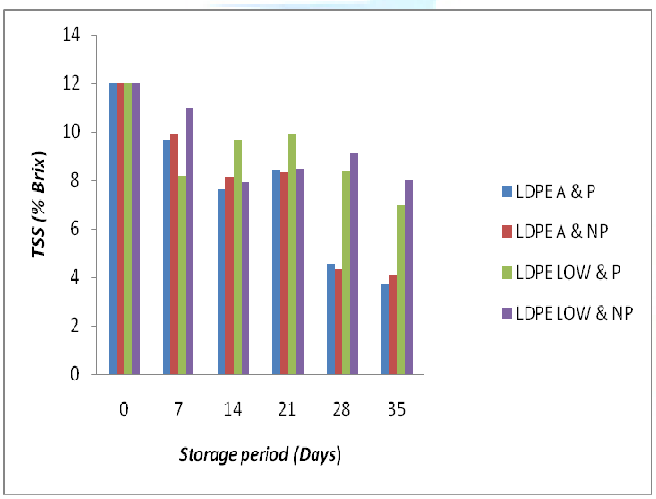

Fig.4.3. Effect on storage temperature, perforated and non-perforated LDPE packaging on TSS of minimally carrot.

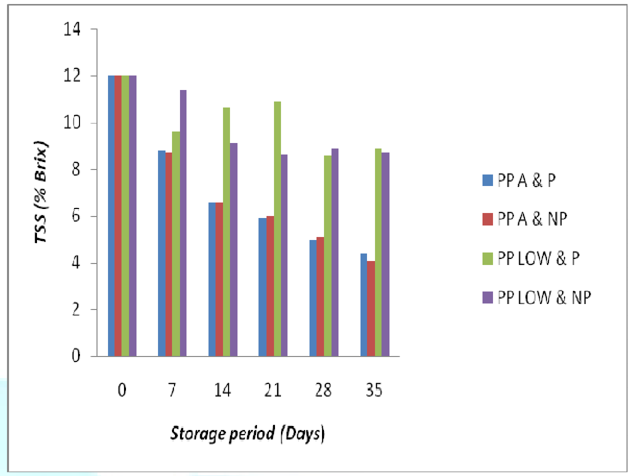

Fig.4.4. Effect on storage temperature, perforated and non-perforated PP packaging material on TSS of minimally processed carrot.

4.3 L* Value

The data of L* value in different treatment combination over the storage period is shown in **Table 4.3.** It is seen that there is an overall increases in L* value for carrot slices at room temperature but the L* values remain almost the same for those sample stored at low temperature over the storage period. The L* values were increased in the sample stored at ambient 21st onwards which may be attributes to the visible fungus growth over sample. The sample stored at low temperature maintained the deep red (blackish) colour the storage period.

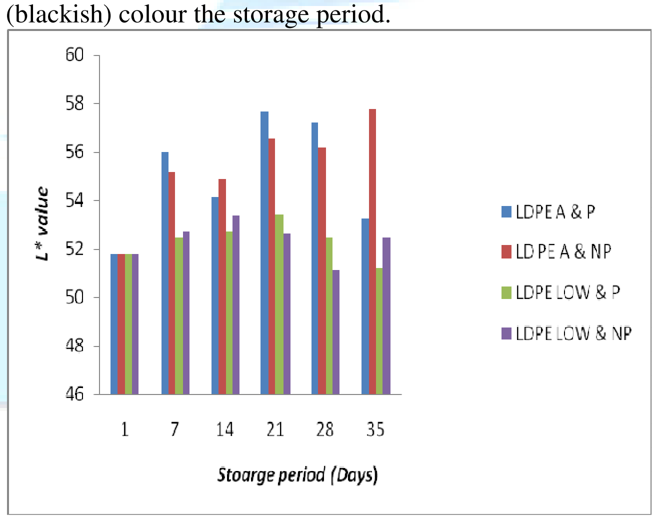

Fig.4.5. Effect of storage temperature perforated and non-perforated LDPE packaging material on L* value of minimally processed carrot.

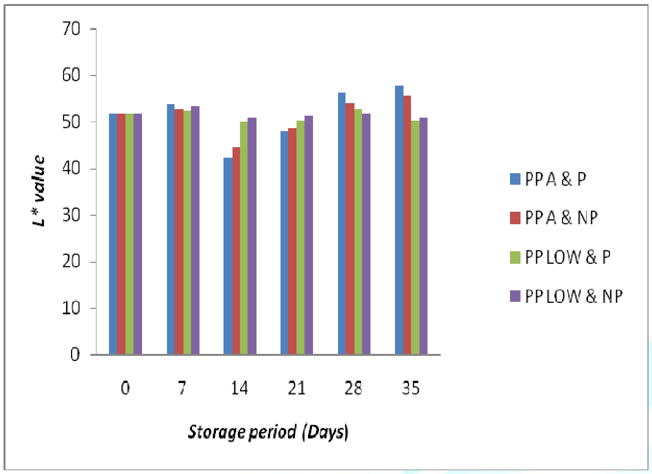

Fig.4.6. Effect of storage temperature, perforated and non-perforated PP packaging material on L* value of minimally processed carrot.

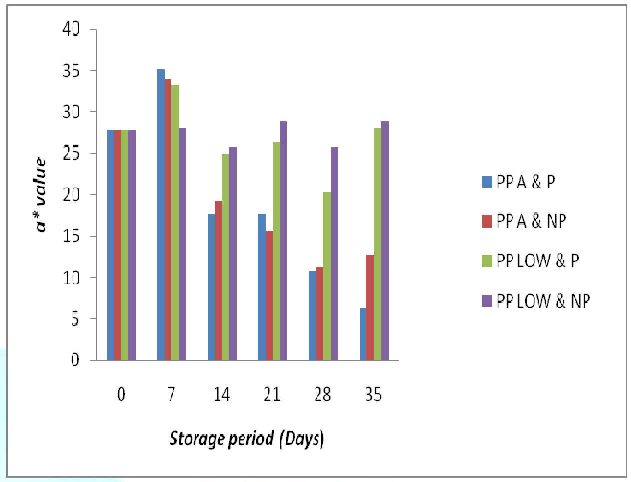

Fig.4.8. Effect of storage temperature, perforated and non-perforated PP packaging material on a* value of minimally processed carrot.

4.4. a* value

The data of a* value in different treatment over the storage period is shown in Table 4.4. From it is observed that throughout the storage period, there is an overall decreases in a* value for sample kept at ambient temperature whereas for those kept at low temperature the value remains more or less constant. The maximum a* value on 35^{th} day was observed kept at low temperature (4^{0}C) in perforated packaging material of LDPE followed by the non perforated one. Similarly the minimum a* value was also found in sample stored at room temperature in perforated packaging material of LDPE followed by the non perforated one.

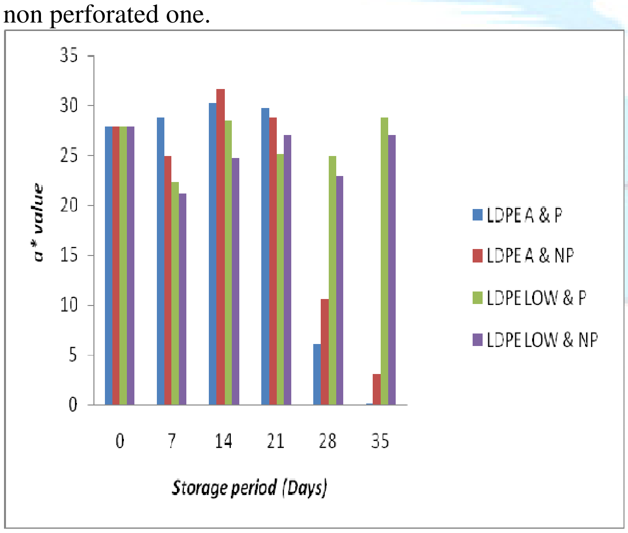

Fig.4.7. Effect of storage temperature, perforated and perforated LDPE packaging material on a* value of minimally processed carrot.

4.5. Beta-carotene content

The content of β-carotene in the carrot packed under modified atmosphere presented the lowest values during the storage period (**Table 4.6.).** The contents of β-carotene decreased continuously during the storage at 4ºC in sliced carrots packed in LDPE and PP bags, with approximately 33% of the initial content after 28 days. Between the 14th and 21st days, there was a reduction in the β-carotene content for all treatment throughout the storage period. **(Pilon, 2006).** It is also clear from graph **(Fig.4.9 & 4.10)** that there is a fast decrease in beta-carotene content the first 14 days of storage period. This may be due to the adoption of sanitization and rising practices and the high solubility of beta-carotene pigment in water that favour large pigment loss due to exposure of the carrot surface to water. On 35^{th} day of storage period greatest loss of pigment was found in sample kept at room temperature in both type of packaging and perforation. The maximum retention of pigment was found in sample kept at low temperature (4^{0}C) in non-perforated packaging material of LDPE followed by perforated packaging material of LDPE and non-perforated packaging material of PP.

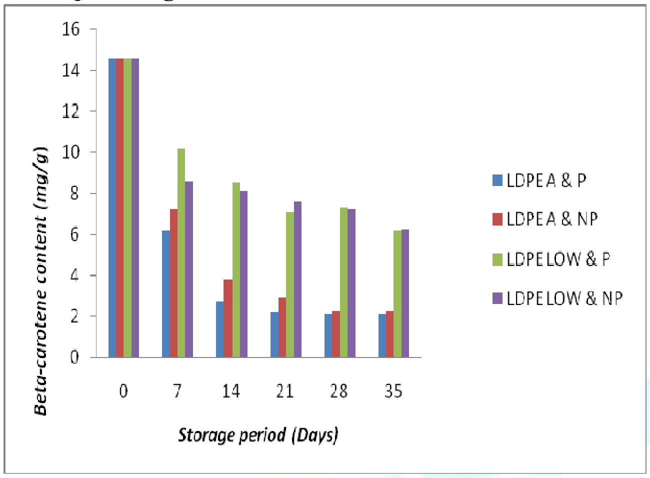

Fig.4.9. Effect of storage temperature, perforated and non-perforated LDPE packaging material on Beta-carotene content of minimally processed carrot.

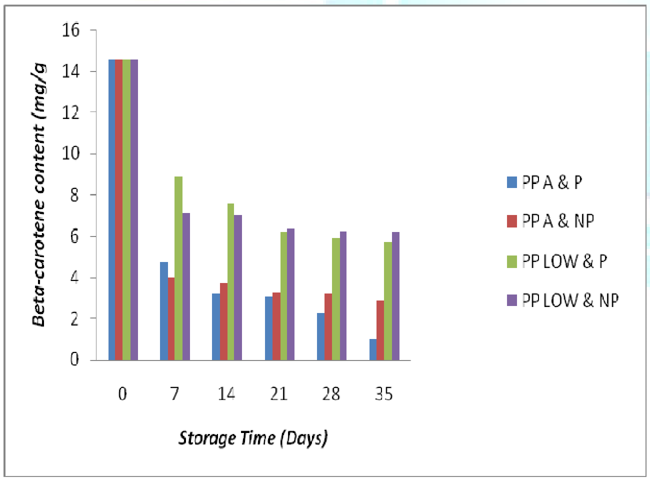

Fig.4.10. Effect of storage temperature, perforated and non-perforated PP packaging material on Beta-carotene content of minimally processed carrot.

4.6. Reducing sugar

The data for the reducing sugar in percent is shown in **Table 4.7.** From the table it is observed that there is an increase in reducing sugar throughout the storage period. On the last day of the storage period maximum gain of reducing sugar was found in sample stored at ambient temperature in perforated packaging material of LDPE whereas the minimum gain of reducing sugar was observed in sample kept in low temperature in perforated packaging material of PP. the accumulation of reducing sugar is undesirable and thus PP at low temperature was found to be better treatment combination.

This accumulation of reducing sugar during storage may be attributed to the invasion of mould and activity of enzyme invertase of sucrose synthetase and temperature because invertase activity in the carrot is normally very low but the activity is sufficient to support the respiration. Again sucrose synthetase is easily reversible and is capable of producing reducing sugar from sucrose. **(Milner & Auigad 1964).**

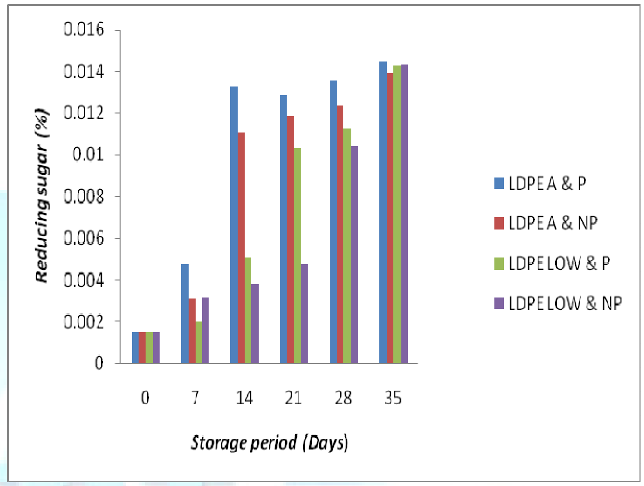

Fig.4.11. effect of storage temperature, perforated and non-perforated LDPE packaging material on reducing sugar content of minimally processed carrot

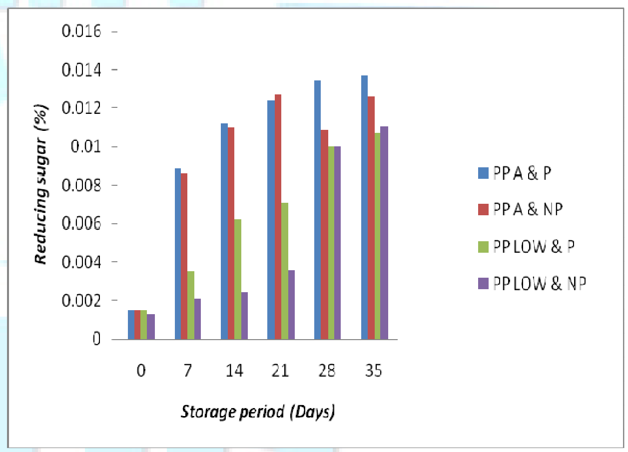

Fig.4.12. Effect of storage temperature, perforated and non-perforated PP packaging material on reducing sugar content of minimally processed carrot

4.7. Total sugar

The data for the total sugar content in terms of percentage is given in table **Table 4.9.** Throughout the storage period a general decreases in sugar was observed for all type of treatment combination. Further from **Fig. 4.13 & 4.14,** a general decrease in total free sugar was observed for all sample stored at ambient temperature. After 21 days of storage period, fungus growth in all sample kept in all sample kept at room temperature and therefore sample were rejected and not used for further quality analysis. On

21st day of the storage period, the lowest amount of total sugar was observed in non perforated packaging material of PP as compared to sample stored in PP with perforation and LDPE with and without perforations. This may be because PP is least permeable and thus package contains higher levels of CO_2 and lower O_2 as compared to other relatively permeable packaging material. On the 35th day of the storage period the maximum retention of sugar was found in sample kept at low temperature in non perforated packaging material of LDPE followed by perforated packaging material of PP at low temperature, perforated packaging material of LDPE at low temperature and in non-perforated packaging material of PP.

The reduction of sugar level may be due to the catabolic activities of acid and alkaline invertase and sucrose synthetase vegetable (**Lavelli *et* al., 2006; wyse & Dexter, 1971**). These enzymes can reduce the yield of extractable sucrose from the carrot directly by their ability to degrade sucrose and indirectly by producing invert sugar. Another reason may be to microbiological activity (**Imura *et* al., 1987**). The transformation of sucrose into invert sugar, raffinose and other organic compounds may also account for the reduction in sugar level during storage (**Wyse *et* al., 1971**).

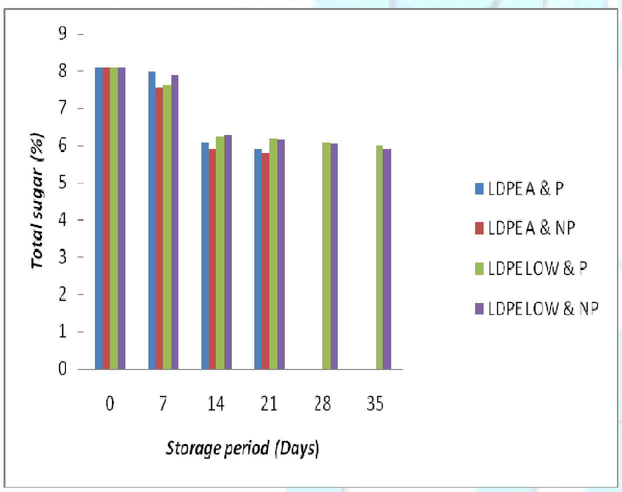

Fig.4.13. Effect of storage temperature, perforated and non-perforated LDPE packaging material on total sugar content of minimally processed carrot

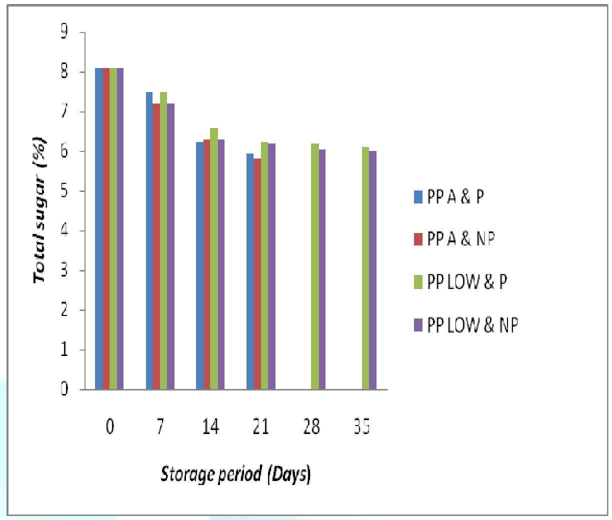

Fig.4.14. Effect of storage temperature, Perforated and non-perforated PP packaging material on total sugar content of minimally processed carrot.

4.8. Organoleptic analysis

From **Table 4.5** it is observed that under all condition of treatment there is a general in acceptability the entire storage period. Carrot packaged in non-perforated LDPE packaging material and perforated PP type packaging material and stored at low temperature were found acceptable up to 35th day.

On 21st day of storage period, the visible fungal growth was observed in sample stored at ambient condition and were not placed for sensory analysis.

5. Conclusions

From the result of the study investigate it was found hat minimally processed carrot can be kept satisfactorily for 14 days in case of ambient temperature storage and up to 35 days in case of storage at low temperature (4^0C) in both the perforated and non-perforated packaging material of LDPE and PP. Increasing weight loss, reducing sugar with considerable decreasing TSS, pigment and sugar content were observed in all stored packs more under ambient condition as compare low temperature storage. Amount the packaging material, non-perforated packaging material of LDPE serve based regarding the reduction weight loss, pigment retention and sugar retention but while considering the TSS, reducing sugar and L* value he perforated packaging material of PP at low temperature storage serve the based packaging material. The maximum a* value was observe in perforated packaging material of LDPE at low temperature (4^0C) However, based on sensory analysis non-perforated LDPE and perforated PP at low temperature storage are more acceptable as compared to other treatments.

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