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Studies on Effect of Storage on Quality of Minimally Processed Babycorn

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Abstract

Every food industry needs that its product should be of high perceptible quality and healthy. Freshly cut babycorn is a perishable commodity and has high respiration rate, so it cannot be stored for longer duration and cannot be transported to distant place under ambient conditions. Modified Atmosphere Packaging (MAP) is intended to create an appropriate gaseous atmosphere in film packages to enhance shelf life and to conserve the quality of the packaged produce. The present study was proposed to assess respiratory dynamics and also evaluate the effect of storage on quality of minimally processed babycorn. Respiration parameters were determined using closed system technique at the temperature viz 5°C, 12.5°C, 20°C and 75% relative humidity. Overall, most suitable packaging and storage conditions for extending the shelf life of babycorn were found to be packaging in 25 micron LDPE packages with 2 perforations followed by storage at 12.5°C.

Keywords: Modified atmosphere packaging; Minimally processed babycorn; Storage; Quality; Overall acceptability

Introduction

It is well-known that minimally processed fruits and vegetables are generally more perishable than the original raw materials [1]. Fruits and vegetables are living, respiring and perishable products with active metabolism even after harvest from the parent plant. Reduction in the shelf life of agricultural produce occurs mainly due to the presence of high moisture. Improper post-harvest management practices are the major cause of losses in fields, packing areas, transportation, and storage and at the wholesale/retail market. The slight discoloration of the cut surface during storage is unacceptable.

Punjab which once a hub of wheat and paddy only is now making a name for itself for its babycorn crop that it exports to the UK and many more European countries. Started from just 40 tonnes in 2006-07, the export figure has touched 500 tonnes. A farmer can produce up to 55 quintals of babycorn per acre. It is a time-bound crop and needs harvesting at the perfect timing. In Punjab, the babycorn seasons are February-March, May-June, August-September and then till mid-December [2]. For babycorn two systems are used. One system uses standard populations of about 58000 plants per ha, where the top ear is left on the plant for grain corn or sweet corn, and subsequent ears harvested for babycorn. The second system uses high plant populations at a spacing of 45 cm×20 cm with 2 plants per hill, having a population density of 175,000 plants ha^{-1}, where all ears are harvested for babycorn. The standard plant populations produce yields of about 46.5 q unhusked ears (4.65 q husked ears) per ha, while the high populations produce yields of about 93-106 q unhusked ears (9.3-10.60 q of husked ears) per ha [3].

Babycorn is a high-value vegetable, with Thailand and Taiwan being the largest exporters. Well drained sandy loamto silty loam soils are best suited for babycorn cultivation. It can also be grown in well drained black soils. In India its cultivation is picking up in an encouraging way in Gujarat, Meghalaya, Western UP, Haryana, Maharashtra, Karnataka, Punjab and Andhra Pradesh [4]. The babycorn must be properly harvested, handled, stored and transported in order to obtain quality produce in satisfactory condition at the place of destination.

Babycorn is a perishable commodity and has high respiration rate, so it cannot be stored for longer duration under ambient conditions and cannot be transported to distant places. The shelf life may be extended, thereby maintaining quality of the produce by appropriate production and harvesting practices, proper on farm handling, and post harvesting practice such as pre cooling, packaging, storage and transportation. Mechanical stress, at the cut surface, cells and membranes reduces the life of freshly cut produce mainly due to damaged leading to alterations in tissue metabolism such as increase in water loss, CO_2, and ethylene evolution, alterations in flavor, aroma, and volatile profiles, increase in activity of enzymes related to enzymatic browning. Various techniques like packaging and low temperature storage need to be adopted to extend its post-harvest life.

Polymeric film wrapping reduces the rate of respiration by creating modified atmosphere around the vegetable and thereby retarding the senescence and ripening [5]. During storage, quality of both packaged and unpackaged produce decreases but it is greater at ambient than at refrigeration temperature [6]. Fresh-cut spinach in LDPE films and storage at 15°C and 75% relative humidity resulted in more retention of chlorophyll, β- carotene and ascorbic acid [7]. MAP is intended to create an appropriate gaseous atmosphere around a commodity packaged in film packages to enhance shelf life and to conserve the quality of the packaged produce [8]. An atmosphere of high CO_2 and low O_2 concentration in a package decreases product respiration and quality deterioration. MAP enables the fresh produce or perishable product to be packaged when it is fresh and then maintains it in that condition, thereby, reducing distribution costs and enhancing flavours and nutrition value for the consumer. In active MAP, the pack is flushed with a gas or a combination of gases. However, the maximum CO_2 (and minimum O_2) concentrations tolerated by fruits and vegetable products vary and are highly related to species [9]. Different films have different CO_2 and O_2 permeability characteristics. Therefore, a film

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may be selected such that the desired gas concentrations are created for a specific product [10]. Other factors that may affect gas concentration profiles have been reported to include package temperature, number of perforations, perforation locations (described by effective length of the package), and air space thickness [10,11]. Also use of more than one perforation on the same package may induce air-draft through the package due to pressure differences in ventilated storage rooms, thus flushing the modified atmosphere in the package.

Modified atmospheres can be achieved by using controlled atmosphere (CA) storage or Modified Atmosphere Packaging (MAP). CA is more appropriate for long term storage, while MAP is used on smaller quantities of produce and the atmosphere is only initially modified. MAP techniques involve either actively or passively controlling or modifying the atmosphere surrounding the product within a package made of various types of films. Active modification occurs by the displacement of gases in the package, which are then replaced by a desired mixture of gases, while passive modification occurs when the product is packaged using a selected film type, and a desired atmosphere develops naturally as a consequence of the products' respiration and the diffusion of gases through the film. Passive MAP is extensively used to extend the shelf life of many fresh commodities and fresh cut fruits and vegetables because passive MAP presents a much more economical alternative approach to Controlled Atmosphere (CA) to extend storage life.

The present study was proposed to study respiratory dynamics of fresh-cut babycorn and to study the effect of storage on quality of fresh cut babycorn.

Materials and Methods

Different theoretical concepts and techniques have been applied by many researchers for minimal processing and modified atmosphere packaging of agricultural produce. The plant material taken for study was babycorn (variety: Syngenta (G5414)), procured from Bharti Field Fresh Farms, Ladowal, Punjab. This variety has good quality and yield and is used for export purposes from Punjab. Experiments were conducted during months from May to December.

Experimental design

Plant material: For this study, fresh babycorn (Variety: Syngenta (G 5414)) were procured from the Bharti Field Fresh, Ladowal, Punjab. The unhusked precooled crop was loaded carefully in plastic crates to avoid any mechanical injury during transportation from the farm to the Fruits and Vegetables Pilot Plant, Department of Processing and Food Engineering, PAU, Ludhiana. The crop was then manually graded and cleaned to sort out any damaged and diseased crop from the experimental lot of crop. The crop was peeled off and sliced (5 mm thick) using cutter knife and chop board and were weighed 200 g each and packed in LDPE bags of 100 gauge with 0 and 2 (1 mm) perforations. The packages (Effective Area: 15 cm×23 cm) were then properly sealed with the help of sealing machine without any leakage (Table 1).

The packaged crop was stored in the Walk-in-cold chamber (Make: Blue Star) at a temperature of 5°C, 12.5°C, 20°C with relative humidity of 75%. Both temperature and relative humidity inside the chamber can be adjusted at desired levels depending upon the storage requirements. Crop packaged was put in a single layer in the plastic crates and crates were placed in the racks inside the chamber. Following parameters were observed at regular intervals during the experiment.

Respiration: The rate of respiration is an important factor to be considered while designing a Modified Atmosphere Packaging (MAP) system. It can be determined in terms of rate of O_2 consumption as well as CO_2 evolution. It needs to be evaluated under different conditions to determine the factors that cause the variations, if any. Packages can be designed taking into account these factors, and the occurrence of injurious oxygen and carbon dioxide levels (O_2 < 1% and CO_2 > 20 %).

Closed system technique: Fresh babycorn procured from the Bharti Field Fresh Farms, Ladowal, Punjab, was dehusked, cleaned, sliced and packaged in 25 micron LDPE packaged sealed and stored in glass jars. All these operations were performed at same environmental conditions (5°C, 12.5°C, 20°C temperatures and 75% relative humidity) as were to maintain during conditions for 2 h before the start of respiration experiment. For each experiment, the volume of sample filled in impermeable container was determined using the relationship;

$$V_s = \frac{W_s}{\rho_s}$$

The total inside volume (V_i) of the impermeable glass containers used for respiration experiment was measured. The density of minimally processed babycorn was determined by water displacement method through the evaluation of true volume of known mass of chopped babycorn [12]. The void volume (V_v) for each experiment was determined using the relationship:

$$Vv = Vt - Vs$$

The respiration study was conducted by placing approximately 1 kg of minimally processed babycorn in each of three impermeable glass containers. Tightly-sealed containers were then placed in an environment chamber (Make: Vista Biocel, Noida India). Three different temperatures viz. 5, 12.5 and 20°C, and constant relative humidity of 75% was used. The container headspace was continuously monitored to determine the O_2 and CO_2 concentrations at regular intervals using a gas analyzer (Make: Quantek Instruments, Grafton,MA). Gas analyses were continued until the difference between two consecutive concentrations in the headspace became almost constant.

$$R_{O_2} = \frac{\left(p_{O_2}^{in} - p_{O_2}^{f}\right)V_v}{100 \times W \times \left(t^f - t^i\right)}$$

$$R_{CO_2} = \frac{\left(p_{CO_2}^{f} - p_{CO_2}^{in}\right)V_v}{100 \times W \times \left(t^f - t^i\right)}$$

The transient state variations in headspace partial pressures and respiration rates observed at different temperatures were studied using

S. No.	Parameter/Item	Description
1.	**Babycorn**	SYNGETA(G5414)-CULTIVAR
2.	**Polymeric film**	Low Density Polyethylene (100 gauge with 0 and 2 perforations)
3.	**Physical Treatments**	Dehusking, hair removal, slicing(5mm)
4.	**Storage temperature**	5°C, 12.5°C,20°C
5.	**Storage relative humidity**	75%
6.	**Observations**	PLW(%), TSS, gas composition, phenol content, sensory evaluation(overall acceptability)

Table 1: Experimental Design

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Statistica Software (Relaease 7.0, Statsoft Inc., Tulsa, OK).

Storage study of minimally processed babycorn crop

Various physical and textural parameters of fresh, stored sliced babycorn (5 mm thick) packed in LDPE-the sliced babycorn (5 mm size) were determined at consecutive days. The gas composition inside the package environment was analyzed daily to know the O_2 composition and CO_2 evolution.

Package headspace gas analysis: The headspace partial pressures of O_2 and CO_2 were analyzed using a portable headspace gas analyzer (Model: 9 Model 902 D Make: Dualtrak, Quantek). The apparatus uses an electrochemical and infrared sensor to evaluate the package headspace partial pressures of O_2 and CO_2. The instrument was calibrated with standard gases before actual experimentation. The sampling probe assembly consisted of one-piece construction to eliminate the chances of leakage of gas samples. The end of sampling probe was fitted with a particular filter and a replaceable needle having tip with dual side port holes to prevent plugging. A miniature pump with electronically controlled timing was used to draw the package headspace sample for analysis. The drawn sample was fed simultaneously to the O_2 and CO_2 sensors. Sensor signals were converted to concentration values of O_2 and CO_2, which were directly read on digital display panel.

Physiological loss in weight (PLW, %): Initial weight of the sample was noted at the time of keeping the sample for storage. The final weight of the sample to be used for analysis was noted at the time of observation. The weighing was done with the digital balance having least count of 0.5 g. The samples were weighed on consecutive days. The PLW at each interval was calculated as:

$$\text{PLW}(\%) = \left(\left(\text{INITIAL WEIGHT} - \text{FINAL WEIGHT}\right) \div \text{FINAL WEIGHT}\right) \times 100$$

Total soluble solids (TSS, ˚Bx): The crop was grated and was tested for TSS using a refractometer. In simplest terms, the refractometer works much like a prism. The modern refractometer works on the principle that it reacts differently to light (by giving a reading on a scale) depending upon the amount of sugar that is available in the liquid sample held between the daylight plate and the main prism assembly. A refractometer allows the user to figure the percentage Brix (the relative "sugar weight" of a sample compared to distilled water) of the fresh sample crop.

Phenolic content (mg/100 gm of fresh weight): The concentration of total phenols was determined as per using Folin Ciocalteu reagent [13]. 1 g of babycorn was extracted with 10 ml of methanol: water (50:50, v/v) solution. 0.5 ml of the diluted (1:10) extract or the standard phenolic compound (gallic acid) was mixed with 5 ml of Folin Ciocalteu reagent (1:10 diluted with distilled water) and 4 ml of aqueous Na_2CO_3 (1M). The mixtures were allowed to stand for 15 min and the optical density of the mixtures was measured against the blank at 765 nm with the help of a UV-Vis spectrophotometer (Model: Spectroscan 80DV, Make: Biotech Engineering Management Company Limited, UK). Standard curve was prepared using 0, 50, 100, 150, 200, 250 µg solutions of gallic acid per ml of methanol: water (50:50, v/v). Total phenol values were expressed in terms of the standard reference compound as gallic acid equivalent (mg/100g , fresh weight [fw] of sample).

Sensory evaluation: The samples packed in different films and stored at selected environmental conditions were examined daily by a panel constituted for the purpose of sensory evaluation. This panel was selected randomly on the basis of gender and age and briefly acquainted with the sensory characteristics that were to be judged and also with the available scales according to which the samples were to be rated. The panel members were requested to assemble at one place prior to evaluation as the samples were required to be judged immediately when opened. Each member was provided with the sensory evaluation rating scales (Table 2) based on which the rating was given to various samples. The average values of the ratings given by all the members were then calculated and used for further analysis. Accordingly, the standard conditions such as Very Good, Good, etc. were defined. The water accumulation conditions inside packages were judged visually to provide them rating according to the scale. Using these scales a scale rate for overall acceptability was developed from consumer acceptance of the produce in the market.

Results and Discussions

Respiratory behaviors of minimally processed babycorn

Respiration rate: The rates of respiration for the minimally processed babycorn were determined at three temperatures (5°C, 12.5°C and 20°C), using closed system technique. The respiration rate with increase in time and with reduction in temperature was found to adopt a regular decreasing pattern [14,15]. The flow lines (Figure 1a-c) show that oxygen consumption rate and carbon dioxide evolution rate is decreasing with increase in time till a time that the difference between two successive values becomes constant value. The steady state oxygen consumption rate was found to be 164.7, 102.83, 72.3 ml $kg^{-1}h^{-1}$ and steady state carbon dioxide evolution rate was found to be 182.13, 53.16, 34.86 ml $kg^{-1}h^{-1}$ at 5 ,12.5 and 20˚C (Tables 3-5).

The variations in the headspace partial pressures and for the impermeable glass containers containing minimally processed babycorn slices sized 5 mm, maintained at different temperatures was studied and the trend observed is shown in graphs (Figure 2a-c). The

Scale	Condition	Rating
Visual Appearance	Very good	5
	Good:Slight	4
	Normal:Moderate	3
	Limited quality :Severe	2
	Not acceptable:Extreme	1
Odour Rating	Normal	10
	Trace Off Odour	8
	Slight Off Odour	6
	Moderate Off Odour	4
	Severe Off Odour	2
	Nauseating Off Odour	0
Water Accumulation	No Water Accumulation	9
	Crop Slightly Wetty	7
	Crop and Film Slightly Wetty	5
	Crop Moderate Wetty	3
	Crop and Film Moderately Wetty	1
	Crop Completely Wetty and Dripping of Water	0

Table 2: Sensory Evaluation Scale

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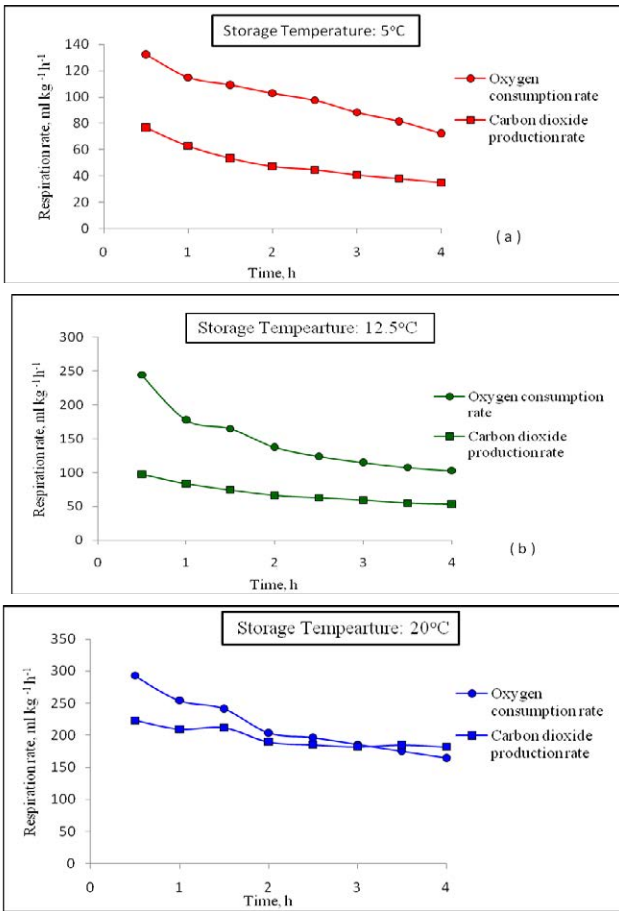

Figure 1: Variation in oxygen consumption rate and carbon dioxide evolution rate during storage of minimally processed baby corn in LDPE packaging film at (a) 5°C ,(b) 12.5°C, (c) 20°C

Time	Temperature at 5°C				
	O_2 Partial Pressure (kPa)	CO_2 Partial Pressure (kPa)	O_2 Consumption Rate(ml $kg^{-1}h^{-1}$)	CO_2 Evolution Rate(ml $kg^{-1}h^{-1}$)	RQ
0	21.1	0.1			
0.5	19	1.2	132.46	76.69	0.58
1	17.8	1.9	115.03	62.74	0.55
1.5	16.4	2.4	109.22	53.45	0.49
2	15.2	2.8	102.83	47.06	0.46
2.5	14.1	3.3	97.6	44.62	0.46
3	13.5	3.6	88.31	40.67	0.46
3.5	12.9	3.9	81.67	37.84	0.46
4	12.8	4.1	72.33	34.86	0.48

Table 3: Respiration Rates Of Minimally Processed Baby Corn At 5°C

partial pressure for oxygen was found to be continuously decreasing and the partial pressure of carbon dioxide increases [16]. The rate decreases as the time progresses with variable temperature conditions. As in case of 12.5°C the rate was quite uniformly observed and faster rates were observed at higher temperature. At lower temperature, the activity for decrease in partial pressure of O_2 was more rapid than increase in partial pressure for CO_2.

Respiratory quotient: The Respiratory Quotient (RQ), was found to follow an increasing trend at 12.5°C, 20°C except at low temperature storage at 5°C where it declined but stabilized to nearly constant or similar values when steady state conditions were achieved [17]. At temperature 12.5°C, it was observed during the first half an hour from the start of the experiment, RQ followed by an increase before gradually stabilizing to a nearly constant value; but very less variation in RQ was observed at 5°C temperature throughout the experiment period. This may be due to the fact that at lower temperatures metabolic activity is lower and so is the respiration rate. Higher temperatures enhance the metabolic rate and substrate (O_2) is consumed at a faster rate thus producing more CO_2 leading to a faster accumulation of CO_2 within the container and causing an increase in the respiratory coefficient even at the initial stage (Figure 3).

Storage studies

Headspace partial pressures of O_2 and CO_2: The headspace O_2 and CO_2 levels in all the packages were observed to be in unsteady state only till the first day of storage and they arrived at steady state thereafter. The headspace O_2 partial pressure in all LDPE packages maintained well above anaerobic levels till the considerable period of storage. Throughout the storage period, headspace O_2 partial pressure remained higher than that of CO_2. CO_2 evolution rate of minimally processed babycorn is nearly less than the O_2 consumption rate, which suggested that small amounts of water vapors could also be produced along with CO_2. On the whole, the lower O_2 levels were observed (Figure 4a-c).

Physiological loss in weight (PLW, %): It is important to measure the physiological loss in weight because it gives an indication about the saleable weight of fresh cut crop sample. All independent factors

Time	Temperature at 12.5°C				
	O_2 Partial Pressure (kPa)	CO_2 Partial Pressure (kPa)	O_2 Consumption Rate(ml $kg^{-1}h^{-1}$)	CO_2 Evolution Rate(ml $kg^{-1}h^{-1}$)	RQ
0	21.1	0.1			
0.5	17.6	1.5	244	97.6	0.40
1	16	2.5	177.77	83.66	0.47
1.5	14	3.3	164.99	74.36	0.45
2	13.2	3.9	137.69	66.23	0.48
2.5	12.2	4.6	124.09	62.74	0.51
3	11.2	5.2	115.03	59.26	0.52
3.5	10.3	5.6	107.56	54.78	0.51
4	9.3	6.2	102.83	53.16	0.52

Table 4: Respiration Rates Of Minimally Processed Baby Corn At 12.5°C

Time	Temperature at 20°C				
	O_2 Partial Pressure (kPa)	CO_2 Partial Pressure (kPa)	O_2 Consumption Rate(ml $kg^{-1}h^{-1}$)	CO_2 Evolution Rate(ml $kg^{-1}h^{-1}$)	RQ
0	21.1	0.1			
0.5	16.9	3.3	292.81	223.09	0.76
1	13.8	6.1	254.46	209.15	0.82
1.5	10.7	9.2	241.68	211.47	0.88
2	9.4	11	203.92	189.98	0.93
2.5	7	13.4	196.6	185.44	0.94
3	5.1	15.8	185.91	182.42	0.98
3.5	3.5	18.7	175.28	185.24	1.06
4	2.2	21	164.7	182.13	1.11

Table 5: Respiration Rates Of Minimally Processed Baby Corn At 20°C

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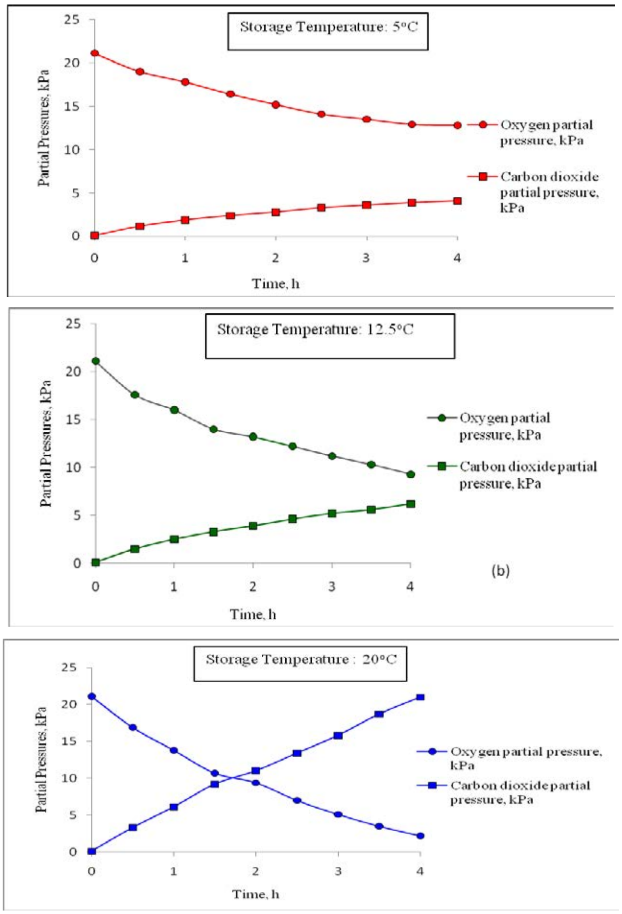

Figure 2: Partial pressures of oxygen and carbon dioxide in the container headspace during the closed system experiment for the measurements of the rates of oxygen consumption (RO2) and carbon dioxide evolution (RCO2) for minimally processed baby corn at (a) 5°C (b) 12.5°C (c) 20°C.

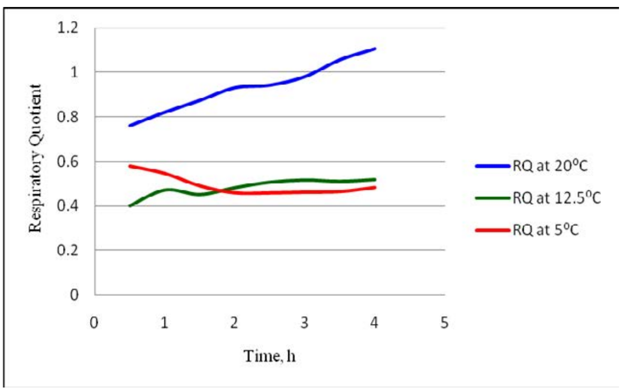

Figure 3: Variation in respiratory quotient with storage time

i.e. packaging film, in-pack weight and storage period had a significant effect on PLW. However, weight loss was not significantly affected by the 2-way interactions between packaging film and in-pack weight. The PLW in percentage of packed samples was evaluated and the results were plotted. It is evident from the graph (Figure 5) that the PLW increased to substantial value and became readily stable at the end of storage period. The perforated packets show more increase in weight as compare to packets with no perforations. Higher temperature with 2 perforations was found to achieve higher values than the stored packages at lower temperatures with no perforation.

Changes in total phenols: Total phenols were calculated at three different temperatures in pack storage with perforation and without perforations. It was observed that in case of no perforations the phenol content was found to be more in amount as compared to pack storage with perforation. It was seen from the trend in the graph

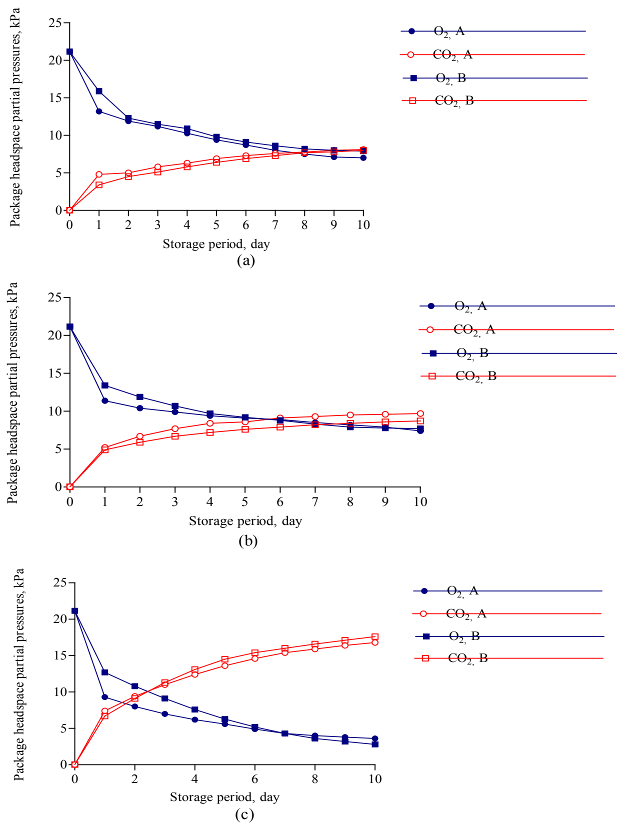

Figure 4: Headspace partial pressures of O2 and CO2 inside low density polyethylene (LDPE) film packages having different perforations (A:without perforations, B:2 perforations) at (a) 5°C,(b) 12.5°C,(c) 20°C, kept for storage under modified atmospheres. The plotted values are means of headspace measurements per packaging treatment along with their standard deviations.

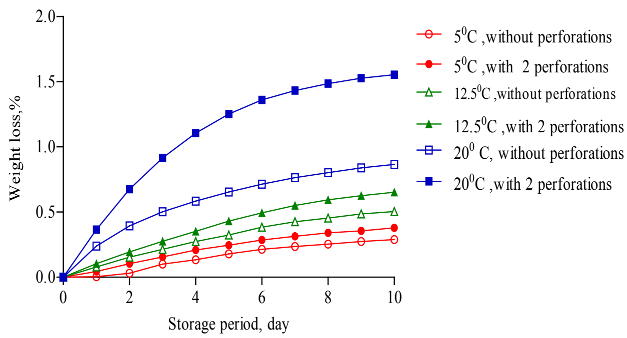

Figure 5: Physiological loss in weight of minimally processed baby corn kept for storage in LDPE film packages at different temperatures (5°C, 12.5°C, 20°C) and perforations(no perforation and 2 perforations) . The plotted values are means of two replications per treatment along with their standard deviations.

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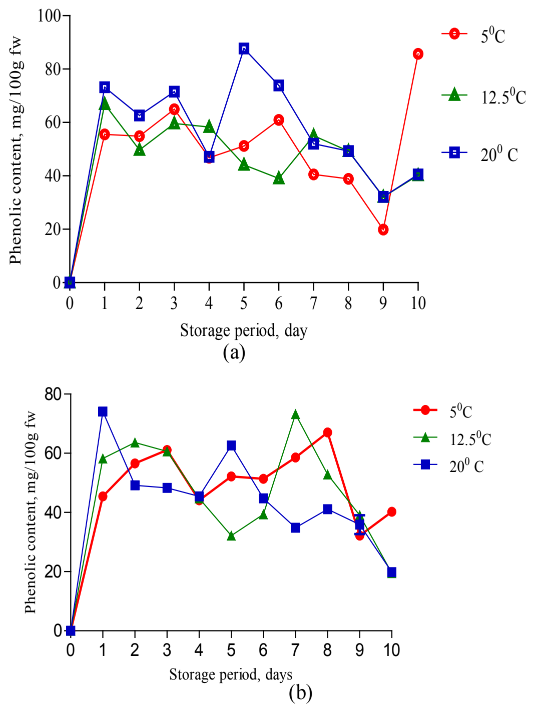

Figure 6: Effect of temperature on phenolic content (mg/100g fw) (a) without perforation, (b) with 2 perforations, of minimally processed baby corn in LDPE.

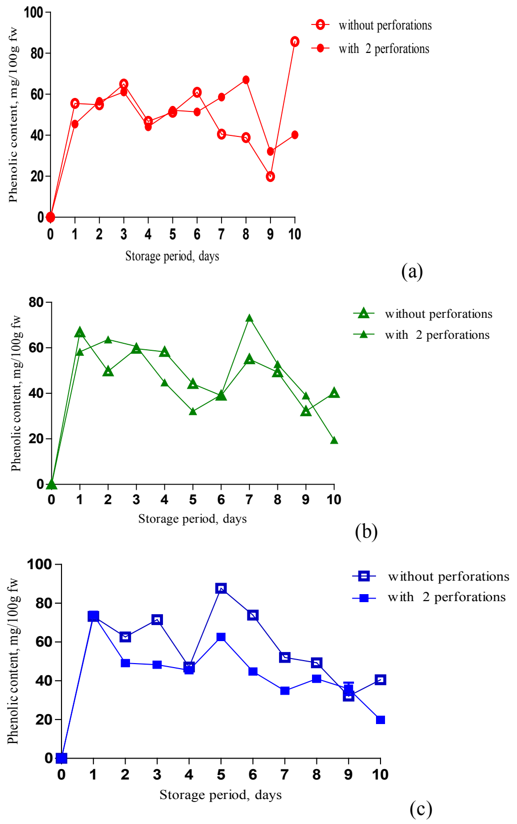

Figure 7: Effect of perforations on phenolic content (mg/100g fw) (a) at 5°C, (b) at 12.5°C, (c) at 20°Cof minimally processed baby corn in LDPE.

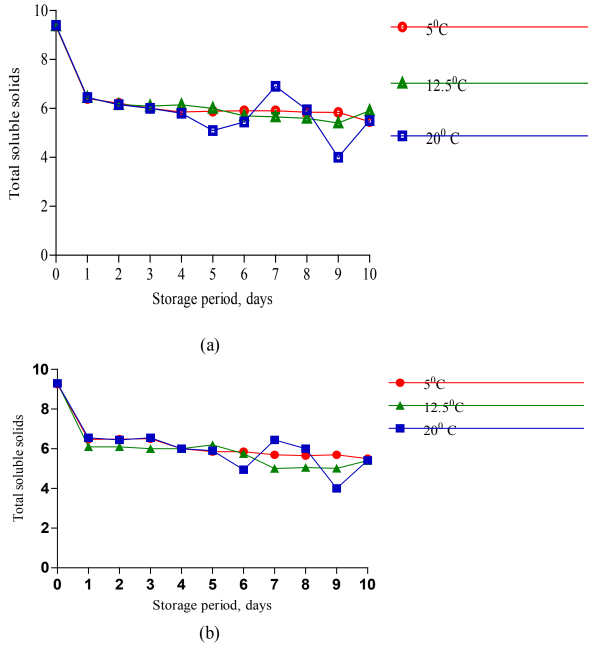

Figure 8: Effect of temperature on total soluble solids (degree brix) (a) without perforation, (b) with 2 perforations of minimally processed baby corn in LDPE.

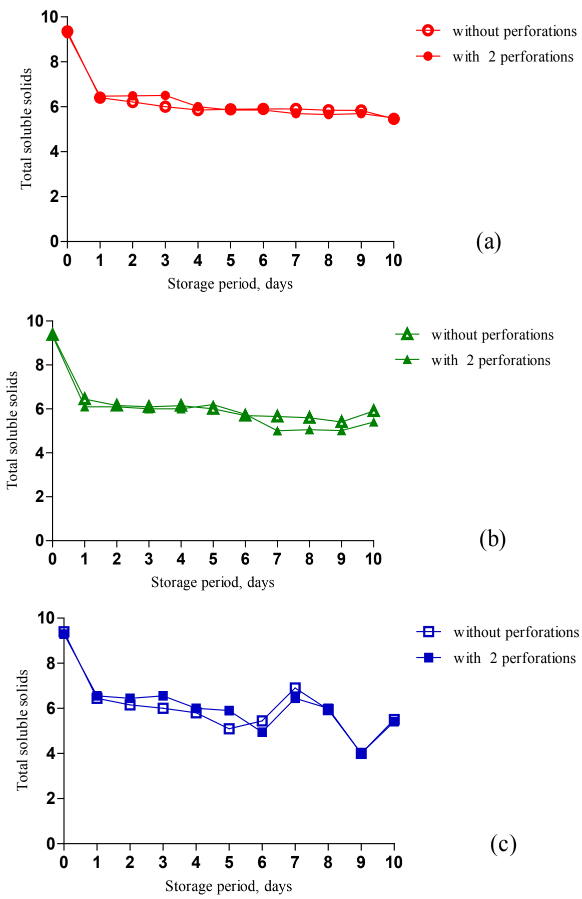

Figure 9: Effect of perforations on total soluble solids (degree brix) (a) at 5°C, (b) at 12.5°C, (c) at 20°C of minimally processed baby corn

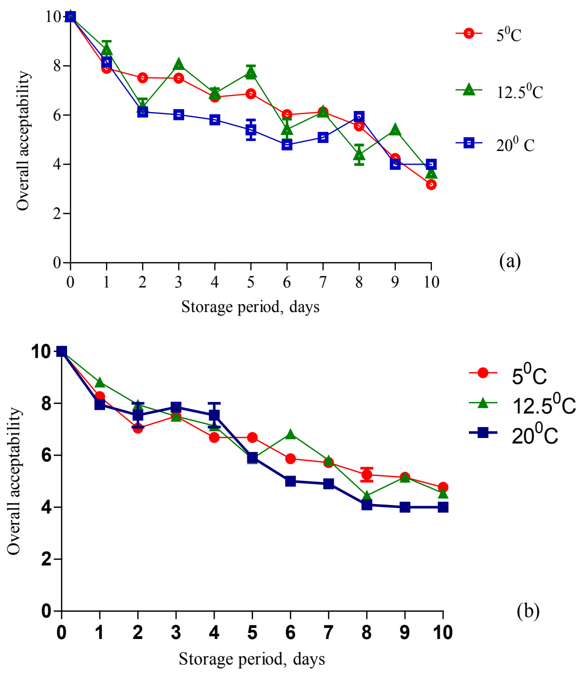

Figure 10: Effect of temperature on overall acceptability (a) without perforation, (b) with 2 perforations of minimally processed baby corn in LDPE.

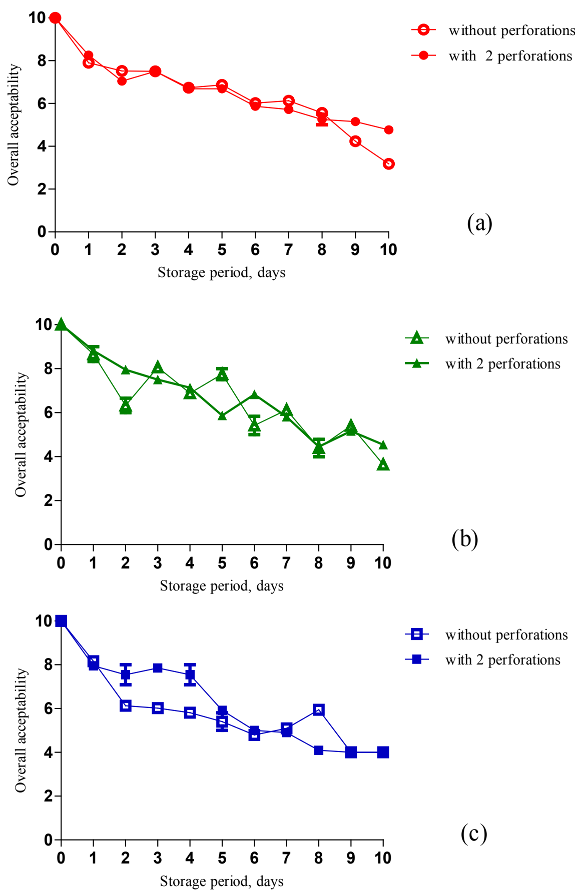

Figure 11: Effect of perforations on overall acceptability (a) at 5°C, (b) at 12.5°C, (c) at 20°C of minimally processed baby corn in LDPE.

(Figures 6a and b, 7a-7c) that package stored at temperature 12.5°C, with 2 perforations, the amount of phenol content at the end of the storage period was found to be least in the quantity as compared to other two temperatures of observation. A pattern with first decreasing values, than abrupt increase in quantity and then again decreases to attain relatively higher value with progress in number of storage days. Maximum value of phenolic content was observed in case of lower temperature storage 5°C that too without perforation. The synthesis of phenolic compounds occurs during storage [18]. However, when the storage time is prolonged, the oxidization of phenolic compounds becomes the major trend and phenolic compounds decrease in cell [18,19].

Total soluble solids (TSS,˚Bx): TSS of the sample crop was observed under varied conditions of pack perforations and temperature of storage. From the trend being followed by the observations being observed during the conduction of an experiment to calculate amount of TSS (Figures 8a,b and 9a-c), it was seen that the pack storage without perforations lead to more amount of TSS accumulated in stored crop as compared to one which has perforations. Also as the temperature rises the enzymatic activity rises and there will be more development of solids in the crop stored [20,21] and so the results obtained, with the rise in temperature, the TSS of the stored crop was found higher than at lower temperature of storage. There is little impact of perforations on storage when sample was observed for TSS. It was concluded that lower temperatures favour less formation of solids in stored crop as per obtained by refractometer.

Sensory evaluation: The stored crop was tested for overall acceptability in the market from consumer point of view. The parameters like visual appearance, odour and water accumulation in the pack storage was rated on different scales by different person expert under the specific field of study and following the set scaled points, an overall acceptability is calculated on the scale of 10. Better results were obtained and observed in case of perforations package as it helps in maintain optimum level of desirability for the product in the consumer markets. As the time follows up, the score rating observed for all samples stored, followed a declining pattern, but at the end, it was observed that packages stored at temperature 5°C, 12.5°C and with perforations were rated best and can be overall accepted from consumption point of view. Whereas the storage period for temperature 20°C reveals that there is no much effect of perforation. But considerable microbiological damage can be observed. The rating scale and the trends can be visualized as in graphs shown (Figures 10a,b and 11a-c). The observation can be attributed to loss in weight, color changes, decay incidence and browning [22].

Conclusion

Vegetables suffer losses in their quality and quantity between harvest and consumption. Appropriate production practices, careful harvesting, proper on-farm handling, post-harvest practices such as pre-cooling, packaging, storage and transportation can contribute in an integrated manner to extend the shelf-life and maintain the quality of such perishables. A grower, who can meet these challenges, will be able to expand his or her marketing opportunities and be better able to compete in the market place [23].

The results obtained from the experiments conducted revealed that the packaged produce had more shelf-life under optimum temperature of 12.5°C with 2 perforations. The respiration rates during storage experiment was found to be least in 5°C, but relative percentage decrease was minimum in case of 12.5°C [14,24-26], so there is less consumption of power and more economical to processor to store the minimally processed produce at relatively less energy waste.

It was also seen that, at low temperature storage, the PLW was minimum in LDPE 100 with 0 perforation followed by 2 perforated film and maximum at 20°C with 2 perforations. It was reported that plastic covering plays an important role in preventing dehydration by creating a saturated micro-atmosphere around the fruit [27]. Reduction in PLW of polythene packed fruits could be attributed to retention of fruits in green fresh and firm form. Moreover, the polyethylene films have the characteristic feature of reducing the rate of transpiration by restricting the diffusion of gases and feedback mechanism.

Maximum value for total phenols in mg/100gm of fresh weight being observed in case of 5°C with no perforations at the end of storage period [28,29] and minimum in case of 12.5°C with 2 perforations. In case of no perforations lower value can be attributed to reduced plant biochemical process, such as production of ethylene, respiration or enzyme activity. The reduction in total phenols could also be explained by the conversion between free and bound phenolic substances [30].

Total soluble solids were found to achieve its highest value in case of 20°C, whereas minimum in case of 12.5°C with 2 perforations. The increase in TSS content at 20°C during storage might be due to the moisture loss, hydrolysis of polysaccharides and concentration of juice as a result of degradation whereas at 12.5°C, probably due to maintenance of humid micro-climate inside these films, which delayed ripening and resulted in slow hydrolysis of starch thus lower TSS.

The overall acceptability was observed to be best in the case of 12.5°C. It was observed during a study on “Nagpur” mandarin fruits that modified atmosphere packaging resulted in significantly higher flavour and appearance score [31].

Keeping in view all the studied parameters, LDPE 100 package film at 12.5°C and 75% Relative Humidity with 2 perforations can be considered the most suitable packaging film for MAP for extending the shelf-life of babycorn which proved to prolong the life of stored product and can prevent it from being damaged through microbial attack or any environmental factors.

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