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Effect of Minimal Processing and Modified Atmosphere Packaging on the Quality Characteristics of Onion (*Allium Cepa* L)

Revathy Baskaran
Principal Scientist, Department of Fruit and Vegetable Technology, CFTRI, Mysore, India
M. S. Krishnaprakash
Retired Scientist, Department of Fruit and Vegetable Technology, CFTRI, Mysore, India
M. C. Varadaraj
Chief Scientist, Department of Microbiology and Fermentation Technology, CFTRI, Mysore, India

Abstract:
The effect of minimal processing (MP) and Modified Atmosphere Packaging (MAP) on the shelf- life and quality characteristics of fresh-cut onions were evaluated. During the storage period of 2 weeks, the cut onion quality attributes were evaluated by way of changes in total soluble solids (TSS), pH, moisture content, color values (hunter colour) and sugar content. The product was also tested for microbial profile and sensory acceptability during and after the storage period of 14 days. During the storage period, there was a slight increase in moisture content and a decrease in both pH and TSS values. Similarly, there was an overall decrease in the sugar content of the stored MP onion. The minimally processed onions packed in Polypropylene (PP) bags of 37microns thickness had a shelf life of ~14 days at 4±2°C retaining all quality attributes, having microbial load within the threshold level (log 6) and had sensory acceptance. It was found that cut onions, which were packed in passive modified atmosphere without pretreatment, lost their sensory attributes at the end of the storage period of 14 days ie., overall quality score for control was 6.5 and for sample that were pretreated and packed under MAP conditions, the sensory score was 8.0.

Keywords: *Minimal processing, Onion, modified atmosphere packaging, Allium cepa*

1. Introduction

Minimally processed (MP) vegetables are those that have been trimmed, peeled and /or cut, washed/ pretreated, packaged and stored at low temperature to offer convenience to consumers (Lamikanra, 2002).

The consumption of minimally processed fresh vegetables is on the increase due to its convenience and freshness (Huxsoll and Bolin, 1989). The main limitation of minimally processed fruits and vegetables is the short shelf-life and deterioration of quality due to tissue damage during processing (Wo Po Park et al.,1998). Hence, MP vegetables need special attention due to rapid respiratory, enzymatic factors and microbiological profile during storage that has impact on the quality and safety. The physiological and biochemical changes are much faster in MP vegetables as compared to intact raw vegetables (Kim et al., 1993). There is no single treatment which is known to control the quality deterioration, but several strategies are employed to achieve high quality MP products. For example use of good quality raw material, following strict hygienic procedures, lowering the temperature, preventing mechanical damage and use of the right packaging material (Lamikanra, 2002).

Modified Atmosphere Packaging (MAP) is an atmosphere created around a produce that is different from that of air, which brings beneficial effect like extension of shelf-life of fresh produce. MAP can be passively created by the commodity itself by the respiration process wherein oxygen is consumed and carbondioxide is evolved or actively by flushing in gases of known composition (Kader et al., 1989).

Onion (*Allium cepa* L), is an important commercial vegetable crop grown in India. India is the second largest producer of onion and they are also exported to other countries. They are one of the basic ingredient in most of the Indian cuisine and their health benefits are well known.

Sweetness is also an important factor in onion flavor. The presence of sugars are difficult to perceive in raw onions due to the pungency of the sulfur based flavor volatiles The three major sugars that have been reported in onions are the fructose, glucose and sucrose. Sweetness in many vegetables is regarded as an advantage as they improve the selling point (Timothy Crowther et al., 2005).

Hong G etal., 2000 have used controlled atmosphere with different gas combinations, along with heat treatment to extend the shelf life of cut green onions.

There are very few studies on the minimal processing of onion, especially passive modified atmosphere packaging along with chemical hurdles. Hence, the objective of the present study was to evaluate the effect of minimal processing operations and passive modified atmosphere on the storage quality of onion during storage at low temperature.

2. Materials and methods

2.1. Sample Preparation, Packaging and Storage

Onions were procured from local market, sorted, graded and peeled manually by removing the uppermost scales. They were diced into cubes of 1cm x 1 cm, given dip treatment in pretreatment solution (Habibunnisa et al., 2002; Patent No.IN192519) for 5 minutes and surface dried using spin drier. Modified atmosphere was created passively through the respiration of the onions itself. For this, around 250 gm cut onions were packed in polypropylene bags (150 gauge /37microns), and hermetically sealed and stored at optimum low temperature (4±2ºC). The samples were withdrawn at periodic intervals (1 week) and analyzed for changes in moisture content, pH, Total Soluble Solids (TSS), total sugars and reducing sugars by spectrophotometric method (Model Labomed Inc, UVD 2950) and free sugars by HPLC , microbiological quality and sensory attributes.

2.2. Analysis of Physico-Chemical Parameters

The changes in the colour of MP onions initially and at the storage period of 14 days were measured by reflectance values using Hunter Lab colout measuring system (Labscan XE system, USA) and expressed as Hunter colour values L (lightness), +a: red, -a:green, +b: yellow and –b:blue (Hunter, 1975).

Total soluble solids (TSS) were determined using a calibrated hand refract meter (0-32°Brix) expressed as soluble solids in terms of degree brix. pH was determined using pH meter (model No. APX 175 E/C). Moisture content was determined by oven dry method (Ranganna, 2005).

2.3. Estimation of Sugars

2.3.1. Estimation of Reducing Sugars

Sugars were obtained by ethanol extraction and the contents of reducing sugars were estimated by DNS method (Miller, 1959). Briefly, 0.2 -1.0 ml of the standards were taken and the volume was made up to 1ml with distilled water. A known volume of the samples were used along with 1ml of distilled water as reagent blank. To these tubes added 1ml of DNS reagent and kept in boiling water bath for 10 minutess. The tubes were cooled and to this added 4ml of distilled water. The color developed was read at 540nm against the reagent blank

2.3.2. Estimation of Total Sugars

Total sugars of the samples were estimated by Phenol-sulphuric acid method. This was done using the method of (Mckelvy and Lee (1969). Pipetted out 0.1- 0.5 ml of the working standard and known volume of the samples in triplicates to different tubes. The volume was made up to 0.5ml with distilled water. To this, added 0.3ml of 5% phenol and mixed well. Added 2ml of concentrated Sulphuric acid to all the tubes and incubated at room temperature for 20 minutes. The color developed was read at 480 nm against a reagent blank

2.3.3. Identification of free sugars by HPLC

10g sample of onion was extracted with 70% ethanol (100ml x 3 times). The extraction was repeated with the residue till the extract tested negative for sugars. The extracts were pooled, reduced to around 5 ml and passed through dowex (H^+) and dowex (OH^-) resins successively and concentrated under reduced pressure at 40 °C. To identify the individual free sugars, the extract was fractionated by high performance liquid chromatography (Shimadzu LC-10A liquid chromatogram fitted with an aminopropyl column of 25 cm length, 4.6 mm diameter and equipped with a CBM-8A system controller, SPD-M8 AVP photo diode array detector), using water-acetonitrile (25:75) as mobile phase at a flow rate of 1.0 mL/min and the eluted sugars were identified using reference standards.

2.4. Determination of Microbiological Quality

Stored samples were tempered to ambient temperature prior to microbiological analysis. Samples 11gm each were blended in 99 ml of 0.85% sterile saline in a Stomacher for 2 min and serially diluted. Aliquots of 0.1 ml of the appropriate dilutions were surface plated in duplicate on pre-poured plates of the following media:

Plate count agar, Potato dextrose agar, McConkey agar and Bromocresol purple agar for Mesophilic aerobes, yeasts and molds, coliforms and mesophilic spore formers respectively, whose growth were taken as the major indices for microbial quality of MP onion during storage. The observations of the incubated plates were recorded and expressed as log units (calculated from colony forming units (cfu) per gram).

2.5. Sensory Evaluation

The cut onions were sauted in drops of oil with little salt to taste and were organoleptically evaluated for major quality parameters like colour and appearance, flavor, texture, taste and overall acceptability using a 9 point hedonic scale (Amerine, Panagbrone and Roester, 1965) by a trained panel of 15 members, both initially and at the end of storage period of 14 days.

2.6. Statistical Analysis

The data were subjected to one way analysis of variance (ANOVA) . All the results are presented as mean and standard deviation of multiple measurements (n=3)

3. Results and Discussion

3.1. Chemical Parameters

There was a slight increase in moisture content in both control and treated samples during the storage period., while in the case of pH and TSS, there was a slight decrease (Table 1).

Parameters	Initial (Day1)		Final (14 days)	
	Control	Treated	Control	Treated
Moisture (%)	85.23±0.83	85.30±0.56	85.47±0.71	85.83±0.45
pH	5.43±0.03	5.27±0.05	5.42±0.08	5.23±0.05
TSS °Brix	13.87± 0.25	13.80± 0.36	13.73± 0.31	13.67± 0.42

Table 1: Changes in quality parameters during storage
Data represents mean ± S.D (n=3)

Color of MP onions was not significantly influenced by the pretreatment, packaging and storage temperature,. The 'L' ie., lightness value almost remained same during storage. The L value was found to be slightly more for treated than control, unlike Siddiq et al., 2013, who have reported that control samples had higher L value when they used mild heat treatment for cut onions. Also, it was observed that in our experiment, there was a slight increase in the yellowness index ie., the 'b' value (Figure 1).

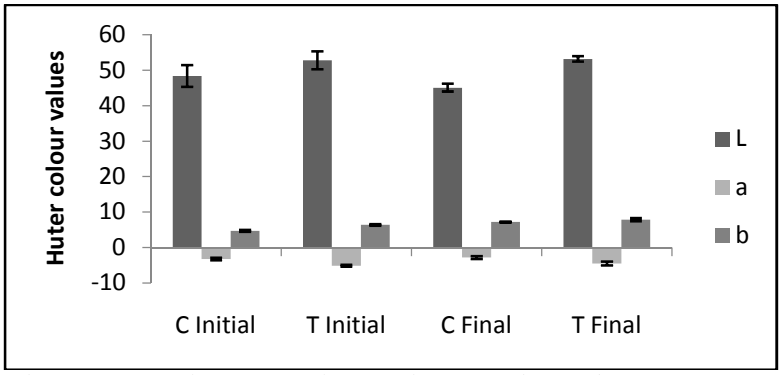

Figure 1: Each value represents the mean of three replicates and error bars represent standard deviation

The sweet taste in onion is one of the important quality characteristics of onions, which can be correlated with the total and constituent sugars present. Total sugars and reducing sugars estimated by spectrophotometric method for the control onions were 6.18 and 3.00 g/100g respectively. On dipping the cut onions in pretreatment solution, there was a slight loss in the total sugar content initially (5.16g/100g) which slightly increased during the storage period (Table 2). This slight decrease could be due to the solubilization of sugars into the pretreatment solution. Also the increase observed in total sugar content could be due to the enzymatic hydrolysis of fructans to fructose and glucose (Shivakumar and Chandrashekar, 2014).

Storage days/Sample	Initial	After 1 week	After 2 weeks
Total sugars (g/100gf.w)			
Control	6.18±0.13	5.04±0.08	6.40±0.16
Treated	5.16±0.11	5.61±0.19	5.74±0.09
Reducing sugars (g/100g f.w)			
Control	3.00±0.07	2.24±0.09	2.88±0.05
Treated	2.50±0.10	2.40±0.13	2.35±0.03

Table 2: Changes in total and reducing sugars during storage of MP onion (Spectrophotometric method)
Data represents mean of three determinations ± S.D , analyzed individually in triplicate

Sanchez Moreno etal., 2004, have found that MAP of onions did not cause any significant change in the content of quercetin, main phytonutrient in onions, which indicates that MAP did not affect important quality parameters of onion, which was also observed in our study.

3.1.1. HPLC analysis of Free Sugars

The major free sugars detected in cut onions were fructose, glucose and sucrose. Onions have been reported to contain these three free sugars (Benkeblia et al., 2002). Changes in soluble sugars showed a similar pattern both in control and treated during the first week of storage. During 2nd and the third week, it was found that there was an increase in fructose and sucrose content. Benkeblia etal., 2002, have reported an increase in fructose content during low temperature storage due to hydrolytic activity of fructan depolymerase. Also, the slight increase in sucrose may be due to conversion of traces of starch present in onions to sucrose.

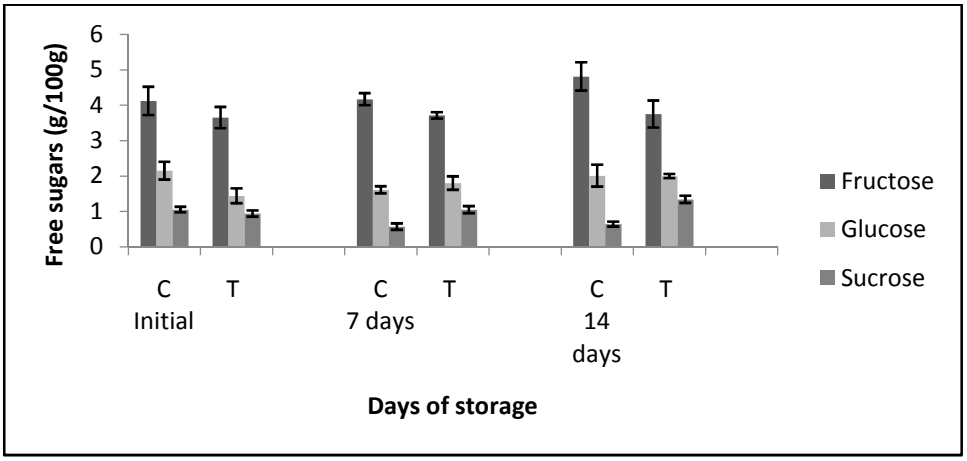

Figure 2: Free sugars content during storage of MP onion
Values are the mean of three determinations ±SD (standard deviation)

3.2. Microbiological Quality

The mesophilic aerobes in control sample was initially log 4.0 which reduced to log 2.6. During minimal processing, the tissue fluid comes out which forms an ideal media for microorganisms. It was observed that in MP onion, the initial microbial load in control was reduced to almost half by dipping the cut onions in pretreatment solution. Similar observation has been reported by Park etal., 1988, wherein the initial microbial load of green cut onions was reduced from 10^4 cfu per gram to half the level by just washing operation. They have also reported that washing with good quality water at low temperature can help reduce microbial load. During the storage of MP onion, it was found that the mesophilic aerobes count decreased gradually in both control and treated samples. This could be due to the effect of gas composition created passively by the commodity, because MAP is known to arrest or delay spoilage. There was no *E.coli* present in any of the samples initially or during storage.

		Initial	Day 4	Day 8	Day12	Day 14
Mesophilic aerobes (log_{10} ; cfu g^{-1}	Control	4.0± 0.9	3.6±0.87	3.8±0.8	3.3±0.5	2.6±0.54
	Treated	2.6±0.4	2.3±0.20	2.3±0.86	1.0±0.07	1.0±0.09
Yeasts and molds	Control	3.1±0.7	2.6±0.95	3.5±0.88	4.0±1.0	2.6±0.6
	Treated	Nil	Nil	Nil	Nil	Nil

Table 3: Microbial profile of minimally processed onion initially and at the end of storage life
Data represents mean ± S.D (n=3)

3.3. Sensory Evaluation

The changes in sensory quality parameters such as colour and appearance, texture, flavor, and taste of MP onions as influenced by treatment and packaging, were evaluated during the storage period of 14 days.

It was found that the both control and treated MP onion were having similar sensory parameters up to 7 days of storage, except that the treated samples had a better texture in terms of crispiness. At the end of the storage period of 14 days, it was found that the control samples deteriorated, became soft, discoloured and had altered flavor, as compared to the treated , which was rated 8.0 on the hedonic scale (Table 4). It was found that all parameters like color, flavor, taste and texture had linear correlation with overall acceptability of fresh cut onions at the end of the storage period. The changes in the sensory parameters were significant at the end of the storage period of 2 weeks.

Storage Days	Treatments	Colour & appearance	Flavour	Texture	Taste	Overall acceptability
Initial		9.0^{a}	9.0^{a}	9.0^{a}	9.0^{a}	9.0^{a}
3^{rd} day	Control	8.6^{a}	8.9^{a}	8.2^{a}	8.7^{a}	8.5^{a}
	Treated	8.8^{a}	8.9^{a}	8.7^{a}	8.7^{a}	8.7^{a}
7^{th} day	Control	7.9^{a}	8.5^{a}	8.0^{a}	8.5^{a}	8.2^{a}
	Treated	8.7^{a}	8.5^{a}	8.5^{a}	8.4^{a}	8.4^{a}
14^{th} day	Control	6.9^{b}	6.6^{b}	6.0^{b}	6.0^{b}	6.5^{b}
	Treated	8.1^{c}	7.8^{c}	8.2^{a}	7.8^{c}	8.0^{a}

Table 4: Sensory analysis of minimally processed Onions stored at 4±1°C
Mean scores with different letters differ significantly by LSD at p<0.05

4. Conclusion

It was found that minimally processed onions given a dip in pretreatment solution in combination with passive MAP and stored at 4±2°C provided a shelf life of 14 days. The fresh-cut onions were microbiologically safe and had good sensory acceptance, whereas the control ie., only passive MAP deteriorated in all sensory quality attributes. The dip in pretreatment solution plus passive modified atmosphere did not alter the quality parameters like moisture, total soluble solids, total sugars, sensory and microbiological quality during storage at low temperature.

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