Colour changes in Indian jujube fruit under modified atmosphere packaging

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Abstract

Colour is an important attribute because it is the first property observed by consumers. The consumer uses colour and appearance factors to provide indication of freshness, flavour and quality. The aim of this study was to evaluate the potential of modified atmosphere packaging in colour retention and preserving quality for Indian jujube fruit. The colour of Indian jujube fruit changes from green to dark brown after harvest as the fruit ripens, and is used as a quality guide for growers and consumers. Fruits at physiological maturity characterized by colour turning stage were harvested and stored in low density polyethylene bags under modified atmosphere packaging. Bags were stored at 6 °C for 35 days. The Colour (L*, a*, b*), chroma and Hue angle were evaluated during storage. The fruit treated with atmospheric condition (21% O₂ + 0.03% CO₂ + balance N₂) lost their quality attributes very rapidly, manifested by accelerated colour changes (L*, a*, b*, C* and h°) but the use of MAP retarded these changes; the efficacy is being higher in fruit packaged with MAP treatments compared to control as a result of the delay in postharvest ripening. MAP with 5% O₂ + 5% CO₂ (with balance N₂) was found best for retention of tristimulus colour coordinates at the end of experiment.

Keywords: fruit quality, jujube fruit, packaging condition

Abbreviations: MAP, Modified atmosphere packaging; CA, Controlled atmosphere; C*, Chromaticity difference

Introduction

Indian jujube (Ziziphus mauritiana Lamk.), also known as Ber, is one of the most important underutilized fruit crop of tropical and sub tropical India, it belongs to the family Rhamnaceae is popularly called the king of arid zone fruits. Jujube is world’s most nutritious fruit and it has received much horticultural attention in India (Morton, 1987). It is rich source of P, K and Fe (Boora and Bal, 2008), vitamin C and amino acids (Jin-Wei et al. 2007), rich in mineral and carbohydrate (Pareek, 1983; Cirasa et al. 1984; Ming and Sun, 1986; Abbas et al. 1988; Pareek et al. 2002). The colour and appearance of fruit attract the consumers at the time of purchasing. The consumer uses appearance factors to provide indication of freshness, flavour and quality. The colour of fruit is derived from natural pigment and changes as the fruit proceeds to maturity and ripening. The primary pigments imparting colour quality are the fat soluble chlorophylls (green), carotenoids (yellow, orange and red) and water soluble anthocyanins (red, blue), flavonoids (yellow) and modified atmosphere packaging (MAP) retarding physiological metabolism and leading to senescence by increased CO₂ and decreased O₂ concentration in the package, slowing down the all metabolic activities and by creating high humidity resulting in less moisture loss and better quality retention (Moleyar and Narasimhan, 1994). Fruit of Indian jujube stored with atmospheric O₂ and CO₂ concentrations as control lost their quality attributes very rapidly, manifested by accelerated colour changes (L*, a*, b*, h° and C*). The use of MAP retarded these betalains (red). Colour of Indian jujube fruit is a major criteria used to judge maturity, ripening stages and grading by growers and consumers. The ripeness stages were characterized by colour measurement. The values of colour difference, chromaticity difference (C*) and Hue difference showed differences between mature green and yellow fruit as a function of ripeness stages (Kovacs et al. 2010).

Modified atmosphere packaging is one of the important techniques for maintaining quality for prolonging the shelf-life period during storage and marketing (Kader, 1986). Modified atmosphere packaging is the replacement of in pack air with a desired gaseous mixture. During the entire storage period no control is exerted over the gaseous composition and it changes with time owing to the diffusion of gases into and out of the package and also due to the effects of physiological process of fruit. If the permeability (for O₂ and CO₂) of the packaging film is adapted to the product respiration, an equilibrium modified atmosphere will establish in the package and the shelf-life of product will increase (Sandhya, 2010). Storage of fruit in modified atmosphere packaging (MAP) retarding physiological metabolism and leading to senescence by increased CO₂ and decreased O₂ concentration in the package, slowing down the all metabolic activities and by creating high humidity resulting in less moisture loss and better quality retention (Moleyar and Narasimhan, 1994). Fruit of Indian jujube stored with atmospheric O₂ and CO₂ concentrations as control lost their quality attributes very rapidly, manifested by accelerated colour changes (L*, a*, b*, h° and C*).
absence of standard recommendations of storage temperature for particular cultivars. This is one of the major constraints faced by whole sellers and retailers. Likewise, studies on application of modified atmosphere packaging for colour and extending the shelf life have not been previously reported in this underutilized fruit. The aim of this work was to study the effect of the modified atmosphere packaging on tristimulus colour attributes of Indian jujube fruit during cold storage and shelf life.

Materials and methods

Plant material

The fruits of Indian jujube cv. “Gola” were harvested from the instructional farm of the Krishi Vigyan Kendra (Farm Science Centre), SK Rajasthan Agricultural University, Bikaner, Rajasthan, India. Mature fruit at colour turning stage were handpicked from trees grown in sandy soil, and were similar in growth and received common horticultural practices. Undamaged fruit, free from visual blemishes, uniform in shape and colour were harvested, graded and transported immediately to the Postharvest Technology Laboratory, Udaipur. On arrival, fruit were washed with chlorinated water; shade dried, and sound fruit of homogeneous size and appearances were selected for giving postharvest treatment.

Gas mixture

The gas mixture (Model MAP Mix 9001, PBI Dansensor, Ringsted, Denmark) was used to mix the desired concentration of O2, CO2 and N2 gases in the packages. The gas cylinders of O2, CO2 and N2 with 99.9 gas purity were used. Polyethylene bags with <100 mL O2 m-2 day-1, O2 and 82.5 mL CO2 m-2 day-1 CO2 permeability (OTR model OPT -500, PBI Dansensor, Denmark) was used to pack the fruits. In MAP, gas mixture of desired composition is introduced within the package either after evacuation or by continuous flow of gas mixture to replace the air (Lee et al. 2010).

Procedure for modified atmosphere packaging (MAP)

After washing and shade dry, the sound fruit were placed inside the low density polyethylene bags (20µ density). 500 g fruits were filled in each bag. In this study seven different gaseous compositions such as control (environmental gaseous composition with 21 % O2 and 0.03 % CO2) and two concentrations of O2 (5% and 2%) in combination with three CO2 concentrations, 5%, 10% and 15% (with balance of N2) were applied with the modified atmosphere packaging machine (Model VAC STAR S 220 MP, Sweden) combined with gas mixture (Model MAP Mix 9001, PBI Dansensor, Ringsted, Denmark). There were three replicates per treatment with 6 units per treatment per replication. Samples were analyzed immediately, and at intervals of 7 days for each treatment during storage to measure effect of MAP treatment on the tristimulus colour of fruit.

Plastic film

Low density polyethylene bags of 20 μ thickness and 500 g fruit holding capacity were used to pack the fruits. Polyethylene films having <100 mL O2 m-2 day-1, O2 and 82.5 mL CO2 m-2 day-1 CO2 permeability are used for packaging of fruit.

Storage conditions

The packages were sealed with MAP and immediately stored at 6 ºC for 35 days, at 80-90% RH. There were three replicates per treatment with 6 units per treatment per replication.

Colour determination

The colour was measured by using a Hunter Lab Colorimeter (model Colour Quest II, Reston, USA), with reflectance mode (RSIN), CIE Lab scale (L*, a* and b*). The instrument was calibrated with a standard white ceramic tile and black tile and set up for D65 as illuminate and a 10º observer angle. Sampling was carried out by loading the quartz cuvettes with fruit sample. The loaded cuvettes were exposed to the aperture and readings were recorded with inbuilt software (EasyMatch QC Software) using a xenon light source under double-exposure conditions. The colour was determined using a CIE L*, a*, b* colour system, where L* indicate luminosity or lightness (L* = 0 for black and L* = 100 for white), and the chromatic parameters a* represent the proportion of redness. On horizontal axis, positive a* indicate a Hue of red-purple; negative a*, of bluish-green. On the vertical axis, b* represent the proportion of yellowness and varies from blue (-) to yellow (+). The chroma C* is calculated from (a*, b*) using the method described by Lopez and Gomez, 2004, as Equation 1: and represents the hypotenuse of a right triangle created by joining points (0, 0), (a*, 0) and (a*, b*). The hº indicated as Hue angle in a colour wheel of 360º (0º = red-purple, 90º = yellow, 180º = bluish-green and 270º = blue) and it was calculated by Equation 2 (McGuire, 1992). The measurements were made in triplicate and each sample was scanned at four different regions to get uniform colour measurement. The colour was determined at 0, 7, 14, 21, 28, and 35 days of storage.

Statistical analysis

All statistical analyses were performed using SPSS 13.0 (SPSS Inc., Chicago, IL, USA). The data were analysed by one-way analysis of variance (ANOVA). Mean separations were performed by Duncan’s multiple range test. Differences at p<0.05 were considered significant.

Results and discussion

Changes in L*, a* and b* value

The colour is an important parameter in purchase decisions, especially when the product is packaged and cannot be touched or smelled (Gonzalez-Aguilar et al. 2000). The effect of modified atmosphere packaging on tristimulus colour of Indian jujube fruit were determined by measuring L*, a*, b* parameters during MAP storage. Analysis of variance showed that MAP had a significant effect (p<0.05) on all parameters (Fig. 1, 2 and 3). Colour changes significantly delayed in fruit stored under 5% O2 + 5% CO2 MAP condition. The fruit treated with atmospheric condition (21% O2 + 0.03% CO2 + balance N2) lost their quality attributes very rapidly, manifested by accelerated colour changes (L’, a’, b’) but the use of MAP
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retarded these changes; the efficacy is being higher in fruit packaged with 5% $O_2$ + 5% $CO_2$ compared with other MAP treatments and control as a result of the delay in postharvest ripening process has also been shown in other fruit, such as persimmon (Ahmed, D.M, 2011), grape fruit (Karacay and Ayhan, 2010; Martínez-Romero et al. 2003), apple (Rojas-Grau et al. 2007), loquat (Amoros et al. 2008) and mango (Pesin et al. 2000) under MAP conditions. The $L^*$ value is an indicator of lightness and increase during storage, changes in $L^*$ value for 5% $O_2$ + 5% $CO_2$ ($L^*$ values increased from 13.40 to 31.49) was slow than fruit packaged in other conditions (Fig. 1). Increasing trend was highest in fruit stored with control due to rapidly degradation of chlorophyll and carotenoids synthesis. The $a^*$ values show increasing trend throughout the storage (Fig. 2) showing colour changes from green to red and lost of freshness.

Changes in Hue angle ($h^\circ$)

Colour (expressed as Hue angle) showed changes during storage which were manifested by reduction in colour in all treatments (Fig. 4). Modified atmosphere packaging had influence on fruit colour during storage. After 7 days of storage, decrease in Hue angle value were detected for all treatments, with higher decrease for control, that differed significantly from other MAP treatments (Fig. 5), although initial Hue value was 87.38$^\circ$ at harvest, while at the end of storage (35 days of storage) fruit packaged with 5% $O_2$ + 5% $CO_2$ MAP gave the best result for Hue 65.18 as compared to 61.80 for control. This noticeable lower decrease in $h^\circ$ values under MAP reduces polyphenol oxidase and enzymatic activities and thus browning. Indian jujube fruit packaged under MAP showed a more acceptable colour and visual appearance, then those stored under control atmosphere condition. This result agreement with result found for fresh cut pear fruit by (Jandric, 2010). MAP treatments probably inhibited chlorophyll degradation and carotenoids synthesis; cold storage and changes in atmosphere during storage of fruits have been found to affect the physiology and biochemistry of the fruits (Artes et al. 2006).

under MAP condition retained the green colour characteristic of freshly harvested broccoli after 21 days of storages and chlorophyll degradation and browning mediated by the inhibition of pheophorbide oxygenase and PPO, responsible for chlorophyll loss and browning, respectively (Beaudry, 2000). In addition, colour preservation by MAP storage has been related to the delay in anthocyanin and carotenoid biosynthesis, thus preserving alteration of colour (Artes et al. 2006). No report has been found in Indian jujube fruit under MAP conditions.

Similar result were found in pear (Soliva-Fortuny et al. 2004) as depletion and slight rise in $a^*$ values. With respect to $b^*$ value, differences existed among all treatments with 5% $O_2$ + 5% $CO_2$ being the best colour retention treatment, while control showed the highest colour degradation at the end of experiment (Fig. 3), similar result was noticed in fresh-cut mango packaged under 10% $CO_2$ + 4% $O_2$ and 86% $N_2$ (Martinez-Ferrer et al. 2002). The most striking feature was found in the morphology of over-ripe fruits (brown colour) due to the middle lamellae of cell walls broke down. Cytoplasm was almost completely destroyed. This fruit was too soft, not suitable for eating as fresh fruit (Kovacs et al. 2010). Accordingly, all individual colour parameters ($L^*$, $a^*$ and $b^*$) significantly increased in unwrapped control broccoli during storage, which was related to both the yellowing process of broccoli inflorescences and the decrease in chlorophyll ($a+b$) concentration. However, broccoli
Fig. 5. Effect of modified atmosphere packaging on chroma (C*) of Indian jujube fruit during storage. Values are the means of three replicates per treatment and sampling point. Vertical bars represent the standard errors of the means.

Changes in chroma (C*)

The chroma C*, an index to colour saturation or intensity (Hunter, 1942; Little, 1975). The chroma (C*) values slightly increased during storage but increasing trend was higher in fruit packaged in control (environmental gaseous composition) as compared to MAP treatments. According to statistically analysis, the applied MAP treatments showed significant effect (P< 0.05) on changes of chroma (C*) values during storage. The minimum changes were found in 5% O2 + 5% CO2 treatments at the end of shelf life where highest in control (Fig. 5).

Conclusions

Results showed that modified atmosphere packaging preserve colour quality of fruits. Indian jujube is a climacteric fruit and low temperatures with MAP inhibited postharvest ripening process. The application of 5% O2 + 5% CO2, MAP with balance N2, found best for preserving of colour quality, freshness, delay postharvest ripening and can ensure a shelf-life up to 35 days of storage. On other hand control (environmental gaseous composition with 21 per cent O2 and 0.03 per cent CO2) induced sharply postharvest ripening, rapidly degradation in colour quality and loss of freshness. The MAP provides better opportunity to growers, wholesaler and retailers by increasing shelf life of fruit, prevent from seasonal glut and by providing raw materials for the processing industry, export earnings, and benefited farmers by selling fruits in off season.

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References


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