

Effect of Vacuum Packaging on Quality of Pomegranate Arils during Storage

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Authors' contributions

This work was carried out in collaboration among all authors. Author APS designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Authors RM and PP managed the analyses of the study. Author AN managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Development of advanced lifestyle increased consumer preference towards preservative free, nutrient rich and ready to eat fresh fruits. Vacuum packaging increases shelf life of fresh produce, reduces quality deterioration by preventing from aerobic spoilage. Safety and quality assurance of packaged fruits/fruit products has concerns world-wide due to quality deterioration and increase in endogenous enzymatic reaction during storage. Minimally processed, ready to eat pomegranate arils are in great demand that satisfy the consumer requirements such as convenient, freshly available, healthy food, and saves time and labor. This study aims to extend the shelf life of pomegranate arils (*Punica granatum L.*) by vacuum packaging. Two different packaging materials such as LDPE and HDPE were used and the vacuum packed arils were stored under ambient and refrigerated conditions. The quality changes & physicochemical properties such as colour, physical weight loss, firmness, pH, titratable acidity, total soluble solids, total anthocyanin content and

microbial load were analyzed. Results indicated that the shelf life of normally packed pomegranate arils were up to 8 days whereas vacuum packed arils were extended to 22 days under refrigerated condition. HDPE has minimal effect on physicochemical properties of arils as compared to LDPE.

Keywords: Pomegranate; vacuum packaging; shelf life; HDPE; LDPE.

1. INTRODUCTION

Pomegranate is well known for its potential health benefits such as its high antioxidant, anti-mutagenic, anti-hypertension, anti-inflammatory and anti-atherosclerotic activity against osteoarthritis, prostate cancer, heart disease and HIV-1 [1,2]. The edible part of the pomegranate is called aril which constitutes about 52% of total fruit (w/w), comprising 78% juice and 22% seeds. In spite of the numerous health benefits, pomegranate consumption is still limited, due to the difficulties in removing the arils from the fruit [3]. Minimally processed & packed pomegranate arils will provide good appeal to the consumers and also enhance the consumption of pomegranate by reducing the time involved in separating the arils [4]. Maintaining the nutritional quality of the arils during storage is difficult due to the occurrence of endogenous enzymatic action, which enhances the respiration rate and increased ethylene production [5].

Most oxygen sensitive produce are gas flushed or vacuum packaged to rapidly attain an atmospheric condition of <1% O₂ in order to slow down the process of browning caused by the oxidation of polyphenolic compounds [6]. Extremely low oxygen and anaerobic conditions may create a potential risk for the growth of pathogenic anaerobic microbes, such as *Clostridium botulinum* [7]. In addition to the method of packaging, the material used plays an important role which protect the produce from external environment & reduces exposure to pathogens and contaminants to extend the shelf life of the produce [8]. Therefore, this study was aimed at the investigation of the effectiveness of different packaging materials and vacuum packaging techniques in extending the shelf life of ready-to-eat pomegranate arils.

2. MATERIALS AND METHODS

2.1 Raw Material

Matured uniform size (Mahalakshmi variety) pomegranate fruits were procured from local

market in Thanjavur. After thorough washing in distilled water fruits were cut into four parts with sharpened knife and then arils were separated manually. Five hundred grams of arils were weighed and were packed in LDPE and HDPE. The packed arils were sealed using vacuum packaging unit.

2.2 Storage

The vacuum packed pomegranate arils were stored at different atmospheric conditions namely ambient, refrigerated (5°C) and frozen (0°C). The frozen aril cell membrane becomes more permeable after thawing, resulted in softening of tissues, discoloration and leaching out of juices from arils in two days after storage. Arils which are stored at ambient conditions also started spoiling from next day onwards. Hence, the study was restricted to refrigerated conditions.

2.3 Physical Loss in Weight (Plw %) & Firmness

The physical loss in aril weight was determined by the ratio of difference in initial and final weight of the arils after storage to the initial weight of arils. The PLW is expressed in percentage (%). Firmness is the indication of fruit quality. The fruit firmness was determined using TA-HD plus texture analyzer (Stable Micro Systems, UK) using P/2 cylindrical probe (2mmØ) with cross head velocity of 1mm s⁻¹ and 5kg load cell, penetrated to the depth of 1mm. The mean value of the firmness was expressed as gram force required for penetrating the aril (gf).

2.4 Total Colour Difference

The colour values were measured using Hunter lab colorimeter (color Quest XE, USA). It works on the principle of measuring the light energy reflected from the sample across the entire visible spectrum. The colorimeter gives L*, a*, b* values where L* represents the degree of lightness from black to white (0 to 100), a* (green to red) and b* (blue to yellow). The colour changes can be measured as the modulus of the

distance vector between the initial colour values and the actual colour coordinates. Total colour difference (ΔE) indicates the magnitude of colour difference between stored and control samples [9].

2.5 pH

The mortar and pestle were used to crush the arils for extracting juice and filtered through cheese cloth. The pH values of the extract were directly measured using pH meter.

2.6 Total Titratable Acidity

Pomegranate juice (5 ml) was diluted in 50ml of distilled water. The total titratable acidity was estimated in terms of citric acid by potentiometrically titrating 3.0 g of diluted juice against 0.1M of NaOH to the end point of pH 8.1. It can be expressed as grams of citric acid per liter [10].

2.7 Total Soluble Solid

The total soluble solid is an index of soluble sugar content in pomegranate arils were measured using digital refractometer (ATAGO-RX7000 α , Japan). It works based on the principle of light refraction (Snell's Law) and the values were expressed in Brix ($^{\circ}$).

2.8 Anthocyanin Content

The total anthocyanin content in the pomegranate arils were measured by spectrophotometric method [11]. This method involved extraction of anthocyanin from aril juice with Ethanolic- HCl solution (a mixture of 95% ethanol and 1.5N HCl in the ratio of 85:15). The optical density of the aliquot was measured using Shimadzu UV spectrophotometer (JAPAN) at a wavelength of 535 nm against ethanolic HCl blank and the values were expressed as mg/100 ml [12].

2.9 Total Phenolic Content

The Total phenolic content in pomegranate arils was determined calorimetrically by means of Folin Ciocalteu method as describe0d by [13].

2.10 Ferric Ion Reducing-Antioxidant Power Assay (FRAP)

Total antioxidant activity was evaluated by using FRAP method. This method measures the ability of antioxidants to reduce ferric to ferrous ion. Add

respective volume of standard (0.1, 0.2, 0.3, 0.4 and 0.5 ml concentrations) and sample (0.1, 0.2 ml) to a set of test tubes. The volume is made to 2.5ml with 0.2M phosphate buffer. Incubate in water bath (50 $^{\circ}$ C) for 20 minutes. Before the incubation, add 2.5 ml of 1% potassium ferric cyanide, vortex well. After incubation cool the tubes and add 2.5 ml of 10% TCA. Vortex the tubes and add 2.5 ml of distilled water. It is followed by adding 0.5 ml of 0.1% ferric chloride then again vortex the tubes well. All the standards and samples were kept for incubation (10 min) at room temperature. The absorbance was read against blank at 700 nm.

2.11 Analysis of Microbial Load

The quality of arils depends on the number and kind of microorganism present, which was assessed by standard plate count method for the enumeration of total microbial load in the sample. 10 g of sample was crushed using mortar and pestle and diluted with 90ml of distilled water. Serial dilutions were made in distilled water. Appropriate dilutions were plated on to the plates of PCA and PDA medium in laminar airflow chamber. Plates were incubated at 37 $^{\circ}$ C for 2 days for total mesophilic aerobic bacteria. Plates were incubated at 22 $^{\circ}$ C for 5 days for yeast and molds. The results were represented as log CFU/g.

2.12 Statistical Analysis

The data were analyzed using Minitab statistical analysis software program, version 17.2.1. The vacuum packaging effect on the quality parameters of pomegranate arils with respect to storage period was analyzed using tukey's multiple comparison tests to determine significant differences ($P \leq 0.05$).

3. RESULTS AND DISCUSSION

3.1 Shelf Life

Pomegranate arils are highly perishable and have shorter shelf life. The shelf life of the arils can be increased by vacuum packaging cause's reduction in gas exchange and respiration rate of the arils. Thus, the highest shelf life of 22 days recorded for vacuum packed arils. The atmospheric packaged arils have minimum shelf life of 4 days under refrigerated condition. This might be due to effective increase in the respiration rate of arils.

3.2 Physical Loss in Weight (PLW %)

The physical weight loss in arils was influenced by method of packaging and packaging material. The lowest (1.85%) and highest (3.46%) PLW was recorded in the arils stored in HDPE vacuum package at refrigerated condition and arils normally packed in LDPE. The lowest PLW in vacuum packed arils might be due to reduced respiration rate whereas, the respiration rate of the arils was higher in control at refrigerated condition.

3.3 Firmness

The textural property for the arils can be predicted by determining firmness. It is found that the peak force required for puncturing the arils stored in LDPE control (46 gf) was less as compared to vacuum package. This might be due to membrane softening and higher moisture loss. Vacuum packed HDPE (131 gf) and LDPE (97 gf) arils required more force to puncture than control.

3.4 Total Colour Difference

The colour characteristics of pomegranate arils are depicted in Fig. 1. Analysis of variance (ANOVA), showed vacuum packaging with significant effect on the pomegranate aril storage ($P < 0.05$). Based on colour change pomegranate aril with different packaging materials during storage are grouped as

follows. Arils stored under vacuum packed HDPE bags shown distinct colour changes ($1.5 < \Delta E < 3$). Whereas, arils stored under vacuum packed LDPE bags showed extremely discrete colour changes ($\Delta E > 3$) from 10th day of storage period onwards. Our results are in coincidence with results of Artes et al., 2000 reported that reduction in anthocyanin content of the stored pomegranate arils after 6 days of storage using perforated polypropylene bags (PPP) [14]. The ΔE values increased with extended storage period and resulted in decreased anthocyanin content. HDPE retained the colour of the arils and showed maximum anthocyanin content. Moisture retention in the arils are influenced by the packaging material. HDPE resulted in minimum water vapour transmission rate and oxygen transmission rate as compared to LDPE.

3.5 Total Soluble Solids

The TSS in pomegranate aril changes during storage period depending on the fruit maturity, variety and storage conditions [15]. TSS of pomegranate arils was significantly affected by the packaging materials and storage period. TSS in pomegranate arils are increased from 14.10 to 16.79 and 15.37 % in vacuum packaged LDPE and HDPE, respectively. Increase in TSS has been attributed to moisture loss, leading to concentration of sugars inside the arils [16].

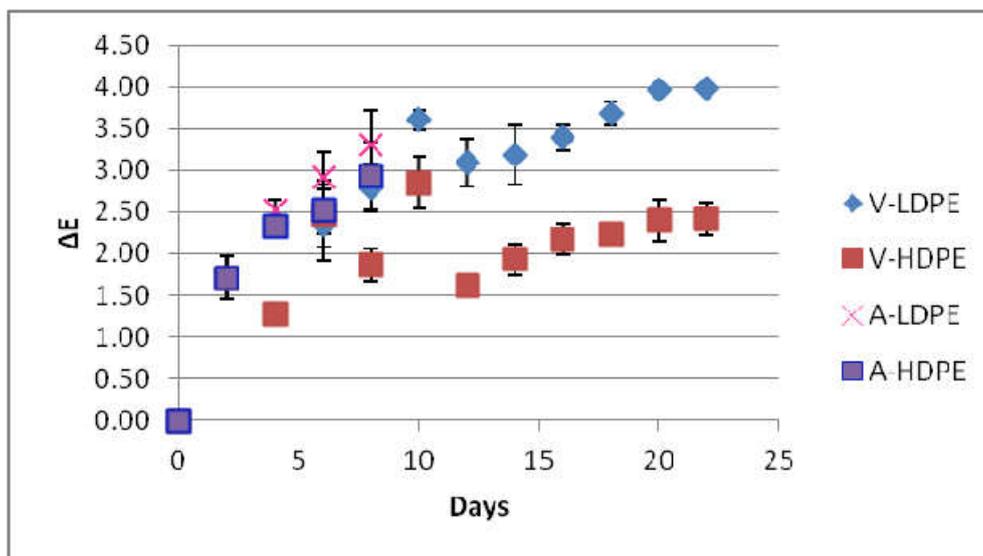


Fig. 1. Total colour difference of Pomegranate arils stored in different packaging materials
 V- LDPE vacuum packed LDPE; V- HDPE vacuum packed HDPE; A -LDPE atmosphere packed LDPE; A - HDPE atmosphere packed HDPE

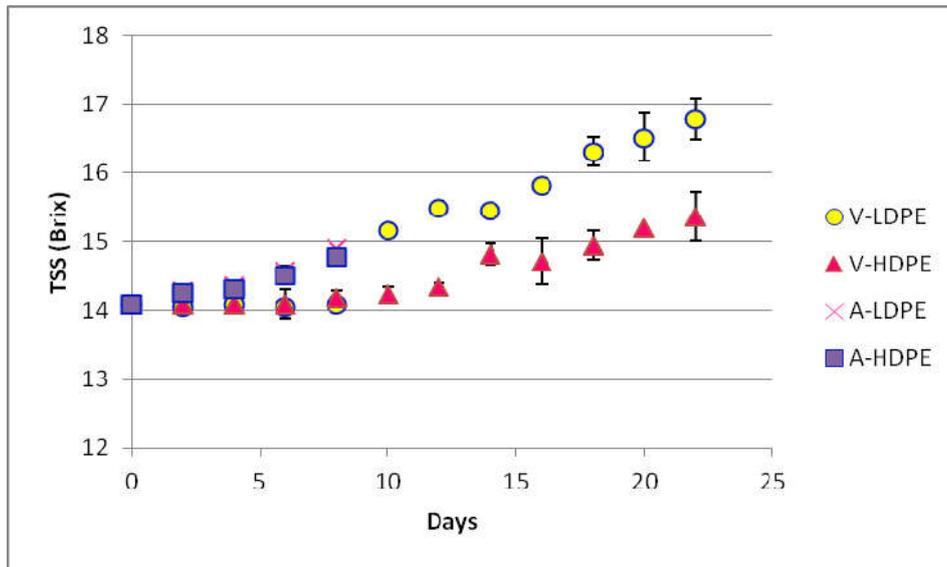


Fig. 2. Total soluble solids of pomegranate arils stored in different packaging materials
V- LDPE vacuum packed LDPE; V- HDPE vacuum packed HDPE; A - LDPE atmosphere packed LDPE; A - HDPE atmosphere packed HDPE

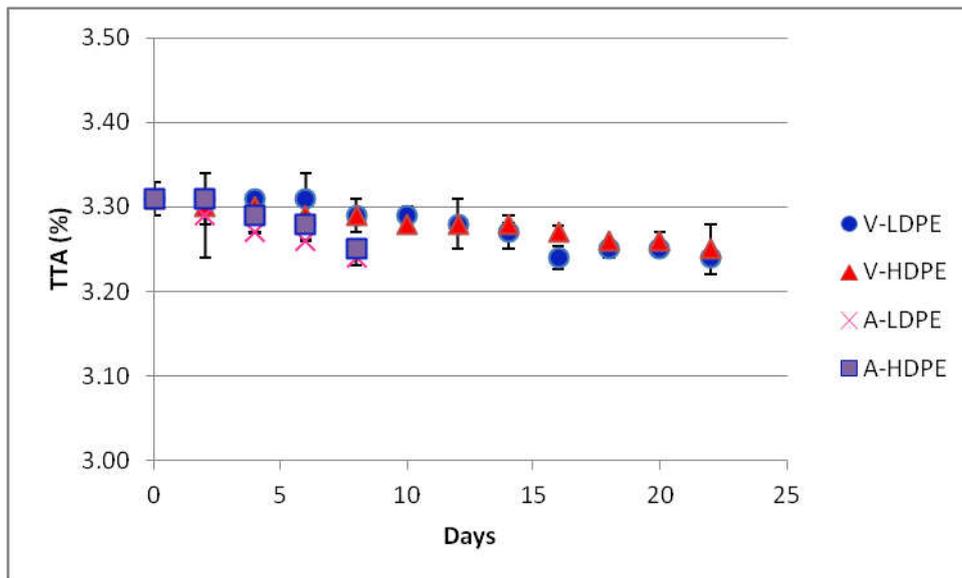


Fig. 3. Total titratable acidity of pomegranate arils stored in different packaging materials
V- LDPE vacuum packed LDPE; V- HDPE vacuum packed HDPE; A - LDPE atmosphere packed LDPE; A - HDPE atmosphere packed HDPE

3.6 Total Titratable Acidity

The total titratable acidity (TTA) of the pomegranate arils were decreased during storage. TTA was decreased from 3.31 to 3.24 & 3.25 for LDPE and HDPE. This might be due to the utilization of sugars as a substrate during metabolic processes [16]. It has been found that there was no significant difference observed for

total titratable acidity of pomegranate arils throughout the storage period.

3.7 Total Anthocyanin Content

Anthocyanin content of arils decreased significantly with increase in storage. The initial anthocyanin content was found to be 8.14%. At the end of storage time, the highest anthocyanin

content was observed in the arils stored under vacuum packed HDPE with 7.97, followed by DPE with 4.91%.

3.8 Microbial Quality

Yeast and mold growth was under the limit of detection for the vacuum packed samples. At the end of the storage (22 days), the aerobic mesophilic bacteria in vacuum packed HDPE were ranged between 2.30 to 4.51 log CFU/g, which is within the permissible limit, i.e., (5.00log CFU/g). Hence it is considered as safe for consumption [17].

4. CONCLUSION

Pomegranate arils can be stored with good quality when it is stored under refrigerated conditions. The physico - chemical and microbial properties of HDPE vacuum packed arils were superior compared to LDPE vacuum packed arils. The shelf life of LDPE and HDPE packed pomegranate arils without vacuum packaging extended the shelf life upto 8 days. Whereas vacuum packed HDPE arils were retained the quality up to 15 days under refrigerated condition. Vacuum packaging with HDPE was found to be suitable for the storage of pomegranate arils.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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