**Influence of Different Modified Atmosphere Packaging on Quality Characteristics of Wonderful Pomegranate Arils**

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**ABSTRACT**

Pomegranate (*Punica granatum* L.) is one of the most favorite fruits which consumed fresh or processed into juice due to its nutritional quality. Fresh cut pomegranate arils have become popular for their ease of eating, highest value, unique properties and health benefits. This study was conducted during the two successive seasons 2017 and 2018. Data revealed all packaging materials in combination with gelatin recorded high score of visual quality along the storage period, after 18 days at 5 ± 1 °C compared with the control. Coating arils in alginate at 3% with Packing in silver nano bag was the effective MPA bags in maintaining taste, aroma and overall acceptability. Also, it recorded the higher value of anthocyanin, vitamin C and antioxidant activity whereas decreased pectinase activity. On the other hand, coating arils in alginate at 3% with packing in Xtend® bag (XT) was prefer able in maintained brightness score and produced lower loss in weight % and oxygen levels inside the package. It could be concluded that coating arils of Wonderful pomegranate in alginate solution 3% then stored in silver nano bag (SN) technology was more effective method to extend storage life of fresh cut pomegranate aril during cold storage.

**Keywords:** pomegranate aril, alginate, modified atmosphere, MPA, Xtend® bag and silver nano bag.

**INTRODUCTION**

Pomegranate (*Punica granatum* L.) is an important fruit crop commercially cultivated in tropical and subtropical regions of the world and viewed as one of the promising exportation fruits products in Egypt in the most recent years Abd-Elghany *et al.*, (2012). Wonderful pomegranate is late cultivar with high yield, enormous fruit, rich red aril, high juice, rich source of bioactive compounds and good attractiveness Palou *et al.*, (2007). Almost all parts of the fruit can be used. The edible part (aril) contains vitamin C, sugars, pectin, amino acids, minerals, fibers, phytoestrogens, flavonoids, phenolic acids Miguel, *et al.*, (2010). Physiological, physicochemical, phytochemical, mechanical, microbial and sensory qualities of pomegranate fruit are impacted by postharvest storage conditions such as temperature, packaging and relative humidity that could be utilized to keep up fruit quality to prolong storage periods Fawole and Opara, (2013).

The success of minimally processed products (fresh cut), favored by social and demographic trends in the world, is linked to the consumer’s present demand for convenient products coupled with perception of freshness and natural taste. Consumer interest for minimally processed produce is growing rapidly, but maintaining product quality has been a significant difficult.

Ma *et al.*, (2010) Types of fresh produce vary widely from fruits, it is hard to protect fresh-cut produce for long storage periods in respiration, transpiration, enzymatic action of the living tissue and microbiological wellbeing. As a rule, the storage temperature particularly impacts the endogenous metabolism of the fruit and microbial decay. At room temperature the pomegranate arils can be stored up to 2 days. The data on broadening its shelf life period is missing and thus it experiences a considerable post-harvest loss. Fresh-cut is more prone to microbial spoilage than whole fruits because of tissue harm; it contains high measures of moisture which lessens its shelf-life Arganosa *et al.*, (2008).

Edible coating is one of the most accepted strategies for prolonging the commercial shelf-life of fruits. The most important advantages of edible coatings are a decrease in the synthetic packaging waste and a contribution to food health and safety while meeting the environmental requirements Garcia *et al.*, (2010). Edible coatings and films are applied on many products to control gas exchange, moisture transfer or oxidation processes. One major advantage of utilizing edible coatings and films is that several active ingredients can be incorporated into the polymer matrix and consumed with the food, thus upgrading safety or even nutritional and sensory attributes.

Alginate is a natural polysaccharide extracted from brown sea algae (Phaeophyceae), and it is made out of two uronic acids: β-D-mannuronic acid and α-L-guluronic acid. Sodium alginate is composed of block polymers of sodium poly (L-gulurionate), sodium poly (D-mannurionate) also alternating sequences of both sugars. Alginate is known as a hydrophilic biopolymer that has a coating function of the fact that its well-studied unique colloidal characteristic, which contains its use for thickening, suspension forming, gel forming and emulsion stabilizing Acevedo *et al.*, (2012). It has several characteristic such as uniformity, transparency and fills in as a superb obstruction to dampness. Specifically, alginate has unique colloidal characteristic permitting its utilization as a thickening specialist and a settling material. It is widely utilized to improve the shelf life of many fruits and vegetables by controlling respiration, diminution dehydration and civilizing mechanical properties Koh *et al.*, (2017).

Packaging play a significant role in keeping up the nutritional and macrobiol quality of fresh or fresh-cut produce. Packaging protects the food products, serves as an alternative measure for controlling diseases and provides structural support for convenient storage and transportation purposes. This play an

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DOI: 10.21608/jpp.2020.110592
important role in extending shelf life of food products and reduces the risk of food borne pathogens (Opara and Mditshwa, 2013).

Modified atmosphere packaging (MAP) with low temperature storage or alone has been successfully used to prolong shelf life of fresh fruit moreover it’s a simple and little price process to lessen these troubles, it can also keep the quality of pomegranate between 12-16 weeks after harvest. In a MAP technique, there is a change in the concentration of gases in the packaging headspace because of the dynamic interaction between the metabolic and biochemical processes of the packaged product. When fruits produce respires, O2 and CO2 ethylene, and water vapor are generated and transfer of all these gases through the packaging is regulated in MAP. The aim of the system is to balance these two processes to provide favorable conditions to preserve the product (Fawole and Opara, 2013). Modified atmospheres are achieved by hermetically sealing fresh respiring produce in polymeric film and allowing the atmosphere within the package to be modified passively by the interplay of produce respiration rate (RR) and the film permeability properties, or actively by flushing the desired gas mixtures inside a package before sealing. Also, they slow down biochemical and physiological processes and retards senescence. MAP keep up arils pigments (anthocyanins) preferable than samples packed without MAP. Thereby maintaining packaged produced microbial safety and freshness, quality attributes. Failure to create this suitable atmosphere may result in a shortened shelf life. Xtend™ packaging passion fruit preserves quality and freshness during storage and shipment by Slowdown respiration and thereby preserving color, fresh taste and nutritional value for longer. Reducing shriveling and decay by removing excess moisture and preserving color, fresh taste and nutritional value for long storage and shipment by suitable atmosphere may result in a shortened shelf life. Each treatment consists of three replicates, each contain 250g arils, 45 bags for all treatments. Pomegranate arils after packaged in different MAP bags as shown in table 1 (Caleb et al., 2013), were stored alone with control for 18 days at 5±1°C. Arils were examined at initial time and during storage every 6 days regarding the following parameters:

### Visual appearance quality (score):

It was evaluated based on the whole visual general appearance in view of taste, aroma, overall acceptability, and brightness by a scale of 9-point rating (Gorny et al., 2002) and Medina et al., (2012) as following:

<table>
<thead>
<tr>
<th>Score</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>9-8</td>
<td>excellent</td>
</tr>
<tr>
<td>7-6</td>
<td>good</td>
</tr>
<tr>
<td>5-4</td>
<td>(fair) limit of consumer acceptability</td>
</tr>
<tr>
<td>3-2</td>
<td>poor</td>
</tr>
<tr>
<td>1</td>
<td>(extremely poor) unacceptible</td>
</tr>
</tbody>
</table>

### Weight loss (%): $= \frac{\text{initial weight} - \text{weight at sampling date}}{\text{initial fruit weight}} \times 100$

### Headspace gas analysis

Before packages were opened on testing date, the in-package atmosphere (O2, CO2) was calculated through storage with attracting up to 2 mL of air samples by using (Dual Trak model 902D gas analyzer; Quantek Instruments, USA) a headspace gas analyzer. At every sampling date, O2 and CO2 values were articulated as percentage.

### Total soluble solids (TSS %):

Total soluble solids were calculated using drops of pomegranate arils juice using a Carl-Zeiss hand refractometer according to AOAC. (2005)

### Titratable acidity (TA %):

It was defined in fruit juice by titration 0.1 N sodium hydroxide (NaOH), using phenolphthalein as indicator and calculated as citric acid according to AOAC. (2005)

### Anthocyanin (mg/100 ml juice):

1 ml of aril juice was blended with 95% ethyl alcohol and 1% HCl, after that it calculated on spectrophotometer (wavelength 535nm). It was calculated as next equations:

$$\text{Total anthocyanin (mg/100 ml juice)} = \frac{\text{Total absorbance per 100 ml juice}}{982}$$

Whereas: (E) value of 1% solution at 535 nm is equal to 982. So, the absorbance of a solution containing 1 mL is equal to 98.2 Ranganna, (1979).

### Vitamin C (mg/ 100 ml juice):

The oxidation of ascorbic acid with 2, 6-dichlorophenolindophenol solution and 2% oxalic acid as a substrate then the results were recorded as mg ascorbic acid per 100 ml aril juice according to AOAC (2005)

### Total phenols (mg/100 gm fresh weight):

Total phenolics fixed by the Folin- Cicalteau method as Singleton et al., (1999) with modifications, based on colorimetric oxidation/reduction reaction of phenols. Gallic

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**MATERIALS AND METHODS**

Pomegranate fruits (Punica granatum L., cv. 'Wonderful') were reaped in 2017 & 2018 seasons from particular orchards at Cairo-Alexandria desert road, Egypt. The fruits were prepared for collect when total soluble solids (TSS) ranged 15 -17 °Brix and acidity below1.85% (Kader et al., 1984) and Martinez et al., (2006). Fruits were transported to the fruits research laboratory and washed with sterile water. Outer skins of healthy fruits uniform in size and manifestation were carefully cut at the equatorial zone with sharpened knife and the arils were manually separated. Arils, were divided into five groups of four them dipped in 3 % alginate edible coating for 1 min dried for 30 min at 25°C, and the fifth one was the control treatment without any edible coating as follows:-

1. **Coating arils alginate3% + packed in polypropylene bag (PP)**
2. **Coating arils alginate3% + packed in Xtend bag (XT)**
3. **Coating arils alginate3% + packed in silver nano bag (SN)**
4. **Coating arils alginate3% + packed in polyethylene bag (PE)**
5. **Control** (packed arils in polyethylene bag) (PE).

### Preparation of edible coatings:

Sodium alginate powder (Sigma-Aldrich) was dissolved in hot water (45°C) at 3% (w/v). After cooling, he add 10% glycerol and 2% (w/v) calcium chloride solution to the alginate solution as a firming agent (Nair et al., 2018).
acid was used for calibration. Results were articulated as mg gallic acid/100 g FW.

- **Pectinase activity**: 0.5 ml arils samples of supernatant enzyme extraction was measured at wave length of 570 nm and expressed as 1 unit of pectinase activity 1 M mol D-galactouronic acid in millilitter/min Miller., (1959).

- **Antioxidant activity**: It was carried out by free radical DPPH according to Bond and Michel., (1997) The antioxidant activity was determined using the next equation:

\[
\text{Antioxidant activity} \% = \left[ 1 - \frac{\text{Abs sample 517 nm}}{\text{Abs control 517 nm}} \right] \times 100
\]

Statistical analysis: Data were analyzed using analysis of variance (ANOVA) according to Snedecor and Cochran (1982). Variations means were statistically parallel using Duncan’s multiple tests at 0.05, using the CoStat V6.4 program.

**RESULTS AND DISCUSSION**

**Visual appearance quality (score)**: The adjustment of the fruit common appearance through the storage period were shown in Fig (1). Despite the treatments, a perceptible decrease was registered with the advancement of the storage period. Control fruits products endured over the top loss of visual quality and before long, became under the constraint of adequacy. As for MAP preserved fruits, in all packaging materials in combination with alginate data exposed high score of chart quality along the storage period, compared with the control. Although coating arils in alginate at 3% +Packed in silver nano bag was the effective MPA bags in maintaining taste, aroma and overall acceptability. While, coating arils in alginate 3% + packed in Xtend bag (XT) was preferable in brightness score. This examination is in line with Mpahilele et al., (2014) and Caleb et al., (2013) renowned that appearance of fruits chart was highly preserved in MAP packages throughout the whole storage period.

Table 2. Influence of MAP with alginate coating on weight loss %, respiration O2% and CO2% of pomegranate arils through cold storage

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Weight loss (%)</th>
<th>Respiration O2%</th>
<th>Respiration CO2%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
<td>6</td>
<td>12</td>
</tr>
<tr>
<td>(T1) Alginate 3% + (PP) bag</td>
<td>0.1</td>
<td>0.4</td>
<td>1.20e</td>
</tr>
<tr>
<td>(T2) Alginate 3% + (XT) bag</td>
<td>0.0</td>
<td>0.0</td>
<td>0.58h</td>
</tr>
<tr>
<td>(T3) Alginate 3% (SN) bag</td>
<td>0.0</td>
<td>0.45</td>
<td>1.20e</td>
</tr>
<tr>
<td>(T4) Alginate 3% + (PE) bag</td>
<td>0.0</td>
<td>0.00</td>
<td>0.67g</td>
</tr>
<tr>
<td>(T5)PE bag (control)</td>
<td>0.0</td>
<td>1.92c</td>
<td>3.53b</td>
</tr>
</tbody>
</table>

**Gas analysis (CO2 and O2):**

Changes in atmospheres headspace of packaged treatments are existed in Tables (2). In both seasons, it was showed a regular significant variations in O2 level in all packaging materials used along with all over the storage period, comparing with the control, i.e. the normal circumstances of atmospheric gas composition (21% O2).Silver nano bag (SN) and polypropylene bag (PP) appeared a steady lessening with the progress of the storage time, began with 10.2 % reaching the levels of (9.0% - 8.90%) in season 2017 and (8.93% - 8.87) in season 2018. On the other hand, Xtend bag (XT) appeared the contrary pattern of O2 level inside the package, starting with 5% increasing to(5.92% - 5.90%) in both seasons. This result matches with the silver nano bag properties, representing that films is breathable polyethylene (PE) material that permits the correct trade of gases inside packages.

Carbon dioxide (CO2) concentrations in headspace of all kinds of practical packages are exposed also in Table (2). A regular change all over the storage period with all treatments is evidently showed.Silver nano bag and polypropylene bag (PP)
appeared a common increase in CO₂ percentage, related with time development. On the other side, CO₂ levels tend to decrease into Xtend bag (XT) significantly in seasons 2017 & 2018. It is essential to note that, effect of MAP technologies neither silver nano bag (SN) nor Xtend bag (XT) does not count mostly on changing the levels of O₂ and CO₂ inside the package. Under these gas creations, both packaging materials had the option to confine weight loss and Keep up fruit quality traits. These results are in accordance with those accomplished by Laribi et al., (2012) who affirm that, in MAP respiration pace of fruits, the vulnerability of the packaging films are the primarily huge significant parameter.

Table 3. Influence of MAP with alginate coating on total soluble solids (TSS %) and titratable acidity (TA %) of pomegranate arils during cold storage

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Total soluble solids (TSS %)</th>
<th>Titratable acidity (TA %)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
<td>6</td>
</tr>
<tr>
<td>(T1) Algin 3% + (PP) bag</td>
<td>15.60 h</td>
<td>15.70</td>
</tr>
<tr>
<td>(T2) Algin 3% + (XT) bag</td>
<td>15.60 h</td>
<td>15.66</td>
</tr>
<tr>
<td>(T3) Algin 3% + (SN) bag</td>
<td>15.60 h</td>
<td>15.63</td>
</tr>
<tr>
<td>(T4) Algin 3% + (PE) bag</td>
<td>15.60 h</td>
<td>15.63</td>
</tr>
<tr>
<td>(T5) PE bag (control)</td>
<td>15.60 h</td>
<td>15.69</td>
</tr>
<tr>
<td>(T1) Algin 3% + (PP) bag</td>
<td>15.90ab</td>
<td>15.94Ab</td>
</tr>
<tr>
<td>(T2) Algin 3% + (XT) bag</td>
<td>15.90ab</td>
<td>15.90Ab</td>
</tr>
<tr>
<td>(T3) Algin 3% + (SN) bag</td>
<td>15.90ab</td>
<td>15.94Ab</td>
</tr>
<tr>
<td>(T4) Algin 3% + (PE) bag</td>
<td>15.90ab</td>
<td>15.98Ab</td>
</tr>
<tr>
<td>(T5) PE bag (control)</td>
<td>15.90ab</td>
<td>16.10ab</td>
</tr>
</tbody>
</table>

**- Titratable acidity %:**

Table (3) cleared that fruit titratable acidity % gradually decreased during the storage period. TA had a regular development through the storage period in all used treatments. A slight reduction in TA in packaged fruits appeared with was less than control at the end of the storage period, yet variations were insignificant. Commonly, the watched decline in acidity with ripening may be accredited to an exhibit of variables, for example transformation of acids to new compounds and minimized capacity of fruits to synthesize acids by maturity. Artés et al., (2000) found the same result on pomegranate with diverse modified atmosphere packaging. In general the changes in TSS in fruits is related with the hydrolytic enzymes for starch as the propelled action of enzymes is liable for the progressions of starch to sugars Laribi et al., (2012).

**Anthocyanin content (mg100 ml⁻¹ juice):**

Table (4) presented a significant reduce by time on total anthocyanin content through seasons 2017, 2018 and regardless of the treatments. The control gave lesser anthocyanin content (11.03 and 11.29) than those of MAP treatments with significant variations in all treatments. While, silver nano bag (SN) packages recorded the higher value of anthocyanin content (12.74 and 13.01) in both seasons, correspondingly. This was in line with Gil et al., (1996), which notified that MAP preserved arils anthocyanins preferable in simile to fruits packed without MAP.

**Table 4. Influence of MAP with alginate coating on anthocyanin (mg100 ml⁻¹ juice) and vitamin C (mg100 ml⁻¹ juice) of pomegranate arils through cold storage.**

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Anthocyanin (mg 100 ml⁻¹ juice)</th>
<th>Vitamin C (mg 100 ml⁻¹ juice)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Initial</td>
<td>6</td>
</tr>
<tr>
<td>(T1) Algin 3% + (PP) bag</td>
<td>13.06a</td>
<td>12.82cd</td>
</tr>
<tr>
<td>(T2) Algin 3% + (XT) bag</td>
<td>13.06a</td>
<td>12.91bc</td>
</tr>
<tr>
<td>(T3) Algin3% + (SN) bag</td>
<td>13.06a</td>
<td>12.95ab</td>
</tr>
<tr>
<td>(T4) Algin3% + (PE) bag</td>
<td>13.06a</td>
<td>12.81cd</td>
</tr>
<tr>
<td>(T5) PE bag (control)</td>
<td>13.06a</td>
<td>12.78cd</td>
</tr>
</tbody>
</table>

**Vitamin C (mg100 ml⁻¹ FW):**

Significantly, all treatments overread the losses of vitamin C comparing with the control as appeared in Table (4) at the end of cold storage. The amount of ascorbic acid decreased continuously with storage prolonged. Vitamin C contents in control treatments descend to 16.84 and 15.93 mg 100 ml⁻¹ FW 18 days at cold storage through both seasons. There were insignificant values between packaged treatments, although the higher amounts of vitamin C contents were obtained in silver nano bag (SN) through the whole storage period. In this treatment the contents of vitamin C were 18.87 and 17.93 mg 100 ml⁻¹ FW at the end of cold storage period in both seasons, respectively. The decline in ascorbic acid in pomegranate at cold storage may be attributed to conversion of...
ascorbic acid into dehydroascorbic acid. The degradation in ascorbic acid during storage may be because of circuitous disintegration among polyphenol oxidase and peroxidase activity. Moreover, ascorbic acid is delicate to oxidative degradation lead to the arrangement of dehydroascorbic acid. Similar result also was observed by Fawole and Opara, (2013).

**Total Pectinase Content (U/g pulp):**

All packaged treatments in Table (5) succeeded with regards to expanding the pectinase content of pomegranate arils season 2017 & 2018. On the other hand, the difference between all MPA packaged treatments was insignificant. Also the data show that, the pectinase content of arils was gradually improved as the cold storage period increased from 0 to 18 days. In this search the lowest values of pectinase content was recorded by arils stored in silver nano bag (SN) treatment (2.11 and 2.26 U/g pulp) through both seasons. On the contrary, the control were recorded the maximum values of this parameter (3.80 and 4.03 U/g pulp). The previously mentioned outcomes are in line with Mahajan et al., (2014) they recorded that, the function of controlled atmosphere packing showed inhibitory effect on pectinase and cellulase enzymes and in delay in ripening, pectinase activity was increased and the lowest activity.

<table>
<thead>
<tr>
<th>Treatments</th>
<th>Storage period (days)</th>
<th>6</th>
<th>12</th>
<th>18</th>
<th>Initial</th>
<th>6</th>
<th>12</th>
<th>18</th>
</tr>
</thead>
<tbody>
<tr>
<td>Treatment 1</td>
<td>Alginate 3% + (PP) bag</td>
<td>1.60</td>
<td>1.56</td>
<td>1.91</td>
<td>2.20</td>
<td>20.15</td>
<td>20.66</td>
<td>21.57</td>
</tr>
<tr>
<td>Treatment 2</td>
<td>Alginate 3% + (XT) bag</td>
<td>1.60</td>
<td>1.54</td>
<td>1.85</td>
<td>2.13</td>
<td>20.15</td>
<td>20.67</td>
<td>21.44</td>
</tr>
<tr>
<td>Treatment 3</td>
<td>Alginate 3% + (SN) bag</td>
<td>1.60</td>
<td>1.51</td>
<td>1.82</td>
<td>2.11</td>
<td>20.15</td>
<td>20.93</td>
<td>21.91</td>
</tr>
<tr>
<td>Treatment 4</td>
<td>Alginate 3% + (PE) bag</td>
<td>1.60</td>
<td>1.60</td>
<td>1.91</td>
<td>2.19</td>
<td>20.15</td>
<td>20.75</td>
<td>21.69</td>
</tr>
<tr>
<td>Control</td>
<td>PE bag (control)</td>
<td>1.60</td>
<td>1.70</td>
<td>2.69</td>
<td>3.80</td>
<td>20.15</td>
<td>20.70</td>
<td>21.43</td>
</tr>
</tbody>
</table>

**Antioxidant activity (GAE µg mL⁻¹):**

Table (5) presented that total antioxidant activity improved as storage advanced. Therere was an increment in antioxidant activity through all treatments compared with the control during both seasons. It also showed that silver nano bag (SN) resulted significant increment in antioxidant activity by DPPH essay approach with all treatments used or the control after 18 days of cold storage (23.54 and 23.10 GAEµg mL⁻¹) in the season 2017 & 2018, respectively. Likewise, control treatment achieved the lowest significant contents of antioxidant activity in pomegranate arils compared with all treatments used (22.04 and 22.06 GAEµg mL⁻¹) in seasons 2017 & 2018. In this respect, Aloui, H. et al., (2014) found that alginate coating improve the AOA in coated fruits. The all out antioxidant activity movement is referred to the sizes of phenolic acids, ascorbic corrosive just as anthocyanin and as such the normal changes in all total antioxidant activity are assorted to those seen for the all out phenolic content. The size of antioxidant activity action is noteworthy quality thought in states of bioactivity and taste Mphahlele et al., (2014).

**REFERENCES**


تأثير عبوات الجو الهوائى المعدل على خصائص الجودة لحبات الرمان الوندرفل

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لا يمكنني قراءة النص العربي من الصورة. يجب أن تكون النص العربي قابل للقراءة للتمكن من المساعدة.