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Gum Arabic and ascorbic acid coating maintains postharvest quality and extends shelf-life of Pomelo (*Citrus maxima*) Segments

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Abstract
Pomelo (*Citrus maxima*) is an unconventional fruit. Though the fruit is reported to have several health benefits its use is limited as peeling of its thick rind is difficult at household level compared to other fruits. Ready-to-eat segments thus are a viable option. A gum arabic based edible coating with 5 per cent ascorbic acid was developed to assess postharvest quality of Pomelo segments. Coated segments were stored alternately in sealed HDPE pouches and vacuum packed HDPE pouches at 5ºC. The results showed that compared to uncoated segments coated ones had higher titratable acidity, ascorbic acid, antioxidant activity and sensory acceptability. Also coating of segments resulted in reduced microbial population. Thus, these results demonstrate that edible coating with ascorbic acid was effective in maintaining quality of Pomelo segments. Also, combination of coating and vacuum packaging was more effective and ideal technique for extending shelf-life of Pomelo segments.

Keywords: pomelo segments, edible coating, ascorbic acid, gum arabic, packaging condition

Introduction

Pomelo (*Citrus maxima*) is also called as Chinese grape fruit, shaddock and pomelo. It belongs to the family Rutaceae. Pomelo is largest of the citrus fruit (15-20 cm in diameter or even larger), borne singly. The rind is very thick (3-4 cm) with a smooth green-to-yellow coloured surface. The fruit commonly have 16-18 large segments (Ladaniya, 2008) [1]. Pomelo fruit is indigenous to tropical regions of Asia, which contains an array of biologically active phytochemicals. It is rich in vitamin C and dietary fibre, which can reduce the risk of cardiovascular disease (Jang *et al.,* 2010) [2]. Though the fruit is rich in nutrients and have many beneficial effects on health. It is considered as underutilized fruit, which is not used for commercial purpose and its use is limited to domestic consumption (Singh *et al.,* 2015) [3].

In order to increase its commercial demand few studies have focused on the development of value-added products from Pomelo. Yadav *et al*. (2013) [4] developed jam and ready-to-serve beverage, Keshani *et al.* (2012) [5], Li-ming and Jin-duo (2018) [6] developed Pomelo juice and wine respectively. But research work on processing the Pomelo fruit with fresh-like attributes was not found. Thus, present study focused on edible coating of Pomelo segments. Edible coatings are generally grouped into proteins, lipids, polysaccharide and composites with the role to prolong the shelf-life of food products and to provide a barrier against hazards. They are involved in inhibiting the loss of moisture and volatile compounds. They can also contribute to the reduction of environmental pollution by virtue of their bio-degradable nature (Del-Valle *et al.,* 2005) [7].

Gum arabic, obtained from stems or branches of acacia species, is the most common polysaccharides used in the industrial sector because of its unique emulsification, film forming and encapsulation properties which has received the highest toxicology safety status by the joint FAO/WHO Expert Committee on Food Additives. It is also a natural biopolymer with wide industrial use as a stabilizer, a thickener, an emulsifier and in additive encapsulation in food industry (Ali *et al.,* 2013) [8]. Gum arabic as edible coating have proven to be effective at extending the shelf-life of some fruits, such as mango (Khaliq *et al.,* 2016) [9] and tomato (Ali *et al.,* 2010 and Al-Juhaimi, 2012) [10, 11].

Ascorbic acid (AA) is an essential vitamin in human health and can be obtained from fruits and vegetables. It acts as an important non-enzymatic antioxidant in fruits and also plays a key role in detoxification of active oxygen (Lin *et al.,* 2008) [12]. Ascorbic acid and its derivatives have been used as an edible coating material in fruits in concentrations ranging from 0.5 to 4 per cent (Sogvar *et al.,* 2016) [13]. Ascorbic acid has been demonstrated in several studies with wide range of application as an edible coating material. Ascorbic acid with chitosan based edible coating improved antioxidant capability of pear fruit (Lin *et al.,* 2008) [12]. Ascorbic acid along with *Aloe vera* reduced vitamin C loss from the strawberry fruit during storage (Sogvar *et al.,* 2016) [13]. AA in combination with lactic acid has antimicrobial effect against *Listeria monocytogenes* and on *Escherichia coli* in carrot juice (Tajkarimi and Ibrahim, 2011) [14].

Extending shelf-life of either fresh or dried fruits and vegetables has been the major concern in the recent past year. Several techniques have been evolved of which, vacuum packaging of processed foods is emerging as one of the important tool considering its advantages in maintaining the shelf-life. Vacuum packaging is the procedure that results in a reduced oxygen level in a sealed package. The anaerobic environment of vacuum packaging prevents the growth of

micro organisms especially aerobic ones which are responsible for off odour, slime and texture changes (Deepa and Chetti 2013, Beltran *et al.*, 2005 and Shah and Nath, 2006) [15,16, 17].

The objective of this study was to investigate the effect of edible coating on Pomelo segment formulated with 5 per cent of ascorbic acid in 18 per cent of gum arabic as base coating material on nutritional, physicochemical, antioxidant activity, sensory and microbial population at fresh, 3, 6 and 9 of storage study and also to assess the effect of two different packaging material (sealed HDPE pouches alone and HDPE pouches + vacuum packaging) on shelf-life of Pomelo segments.

2. Material and Methodology

2.1 Preparation of Pomelo segments

Healthy Pomelo fruits without any physical damage and fungal infection were purchased from Devanahalli local fruit sellers. Selected fruits were minimally processed by washing under running tap water, peeling of cleaned Pomelo fruit which was done manually. Fresh segments were separated from albedo and flavedo of fruit using peeling tools under sterile condition, in the Department of Food Science and Nutrition laboratory at GKVK, UAS, Bangalore.

2.2 Preparation and formulation of edible coating materials

Gum arabic as base material with different concentration (10, 12, 14, 16, 18, 20, 25, 30 and 35 per cent) was tried for coating the segments. Among them 18 per cent was accepted because of its good film forming and even distribution consistency without any air gap on surface of segments. Ascorbic acid at 1, 3 and 5 per cent concentrations in 18 per cent gum arabic gel were tried on repeated laboratory procedures among them 1 and 3 per cent showed no effect on shelf-life extension of the Pomelo segments whereas 5 per cent concentration showed desirable impact on storage of Pomelo segment. Hence, 5 per cent ascorbic acid was standardized for further treatment in the present study.

2.3 Coating and storage condition

Selected Pomelo segments were coated by brushing method and then were dried under shade with constant stream of circulating air at room temperature. Then segments were stored under two different storage condition (HDPE pouches alone and HDPE pouches with vacuum packaging). These packs were kept at 5°C in a refrigerator condition for storage study. Nutritional, physicochemical, antioxidant activity, sensory and microbial analysis of control (un-coated) and coated segments were performed for every fresh and on 3, 6, 9 days of storage.

2.4 Moisture

Moisture content was determined gravimetrically by accurately weighing the sample into petri dish and dried in an oven at 70 °C. Same procedure was repeated for several times, till the weight of the petri dish with its content becomes constant. Each time before weighing, the petri dish was cooled in desiccator. Moisture content of the sample was expressed in g/100g of sample (AOAC, 1980) [18].

2.5 Ascorbic acid

Ascorbic acid content was estimated by indicator method. This method is based on stoichiometric reduction of the dye 2, 6 – dichlorophenol indophenol by ascorbic acid into colourless compound. Dye factor was calculated using series of standard ascorbic acid concentration, which was titrated against the standard dye. An aliquot of 10ml of sample extract was titrated against standard dye to a pink end which persisted for 15 seconds. The filtration was conducted in the presence of oxalic acid (Ranganna, 1986) [19].

2.6 Antioxidant Activity

Antioxidant activity was determined by the 2, 2 – diphenyl-1-picryl-hidrazil (DPPH) radical scavenging method described by Kavita *et al.* (2013) [20]. 5 g of sample was homogenized with 10 ml 80 % methanol (10 ml × 4 times). All extracted samples were pooled together, filtered and marked up to 50ml using 80% methanol. 0.2ml of extracted sample was taken to test tube and 0.3ml of acetate buffer, 0.8ml of 80% methanol and 2.5ml of DPPH were added to it and mixed vigorously. Simultaneously, blank sample was prepared using 0.3ml of acetate buffer, 1ml of 80% methanol and 2.5ml of 0.02Mm DPPH. All the tubes were incubated in a dark place for 30min and absorbance was measured at 517nm. Total antioxidant activity was calculated using standard curve and was expressed as ascorbic acid equivalent (AAE/100g).

2.7 Total soluble solids

The coated and control (un-coated) Pomelo segments were ground in a blender and juice from the samples was used to determine the total soluble solids (TSS) using digital pocket refractometer with 0-53° brix range (ATAGO make, model: PAL-1). The machine was standardized using purified water before readings were taken. Total soluble solids values were expressed as °brix.

2.8 Titratable acidity

Titratable acidity (TA) was determined using the method described by Ranganna (1986) [19]. A known quantity of fruit was blended with distilled water and volume made up to 100 ml. An aliquot was taken from this sample and titrated with 0.1N NaoH using few drops of 1% phenolphthalein solution as indicator. The appearance of pale pink colour was marked as the end point. Acidity was computed and expressed as per cent oxalic acid.

2.9 Colour

Colour changes were recorded using the Munsell colour chart where the symbol for hue is written first and is followed by a symbol written in fraction form, the numerator indicating the values and the denominator indicating the chroma (H V/C). Hue (H) indicates the name of colour; value (V) the lightness of the colour and chroma (C) the purity of the colour. When making colour comparisons, sample was viewed alongside the standard chart normally, that is, at about 90° while the light fell at an angle of about 45° (Munsell, 1952) [21].

2.10 Sensory evaluation

Sensory evaluation of Pomelo segments was done by a panel of semi trained members (n=10) from the Department of Food

Science and Nutrition, University of Agricultural Sciences, GKVK, Bangalore, on 5-point hedonic scale (5- excellent, 4- good, 3- fair, 2- poor, 1- terrible) for colour, visual inspection for spoilage this characteristic was termed as "absence of spoilage", glossiness is one of the important index in assessing fruit quality which was attributed to shiny or lustrous appearance (Mizrach *et al.,* 2009) [22], firmness was assessed by pressing the segments by holding it in between thumb and two fingers, aroma was identified by holding the fruit close to nose and sniffing, uniformity of the skin was attributed to fruit surface without any wrinkles on it, hand feel was measured with range from slimy to fleshy and taste was ranked by panel members in order to identify the dominant flavour of coating over typical taste of fruit (bitter sweet).

2.11 Microbiological evaluation

Total bacterial and mould population were carried out for microbiological analysis of coated and control (un-coated) Pomelo segments using potato dextrose agar (PDA) as medium for 9 days of storage. The plates were incubated at 35°C for 7 days. Bacterial and mould counts were determined using the pour plate method (Naguz *et al.,* 2005) [23]. All microbiological analysis was carried out in triplicates and the results were expressed as $\times 10^3$ colony forming units per gram ($\times 10^3$ CFU/g).

2.12 Vacuum packaging

Vacuum packaging was carried out by exclusion of air from the bag with a gas exchange device (Elixir make, Model: MAP 270 GS). The gas permeation values (pressure 99 units, seal 9 with 3 seconds of time) for HDPE films were provided by manufacturer. Coated and uncoated Pomelo segments were stored in HDPE pouches under vacuum packaging condition at 5°C. The storage study of coated and uncoated (control) Pomelo segments were done for 9 days. These were evaluated for moisture, vitamin C, antioxidant activity, titratable acidity and total soluble solids content at interval of fresh, 3, 6 and 9 days.

2.13 Statistical analysis

The data was tabulated using factorial two-way analysis of variance for storage study, antioxidant activity and nutritional and physicochemical content of edible coated segments. Analysis of variance (F-test) was done for sensory characteristics to test the significant difference between coated and uncoated segments. The data was analysed using OP stat online software. Significant difference was defined at $p \leq 0.05$.

3. Results and Discussion

3.1 Formulation of coating material

Ali *et al.* (2010) [10], Al-Juhaimi (2012) [11], Khaliq *et al.* (2016) [9] and Ali *et al.* (2013) [8] also found gum arabic as a novel base material at 5 to 20% concentration for coating in tomato and mango fruit, which contributed in extending their storage and reducing postharvest decay because of its antimicrobial property. Similar results were found in the present study, where gum arabic with 18 per cent of concentration had good film forming property and showed even distribution on the surface of Pomelo segments. Compared to other concentrations (10, 12, 14, 16, 18, 20, 25, 30 and 35 per cent) it was neither watery nor thick. Hence, 18 per cent concentration of gum arabic was acceptable for the present study as base coating material. Result on use of gum arabic as base material with 18% showed good adhesion and spreading property with no air gaps.

Ascorbic acid at 1, 3 and 5 per cent concentrations in 18 per cent gum arabic as base material were tried on repeated laboratory procedures among them 1 and 3 per cent showed no effect on storage extension of the Pomelo segments whereas 5 per cent concentration showed desirable impact on storage of Pomelo segment. Hence, 5 per cent ascorbic acid was standardized for further treatment in the present study. These results are on par with Sogvar *et al.* (2016) [13], Lin *et al.* (2008) [12] and Tajkarimi and Ibrahim (2011) [14] study who showed 5 per cent concentration of ascorbic acid as the best in coating strawberry, pears and carrot. According to these reports ascorbic acid in coating material improves quality and extends storage of fruits because of its antioxidant and anti-microbial property.

3.2 Moisture

Increase in moisture content during postharvest storage of fresh produce leads to change in texture, flavour and appearance (Lin and Zhao, 2007) [24]. Present study showed significant difference ($p \leq 0.05$) in moisture content between the segments. However, increasing trend was observed in both coated and uncoated (control) segments (Table. 1). But, by the end of the storage period moisture content was slightly higher in uncoated (88.38 %) than coated (88.13 %) segments. This was due to increased respiration rate in uncoated segments, while in coated segments coating act as barrier to moisture loss, thus maintaining moisture content throughout storage period. These results are supported by Ayranci and Tunc (1997) [25] on apricot and green pepper coating with methyl cellulose, polyethylene glycol and ascorbic acid coating material. Similarly, Qi *et al.* (2011) [26] study on fresh cut apple with ascorbic acid and chitosan based edible coating. They suggested coating with ascorbic acid had better moisture retention property.

3.3 Titratable acidity (%)

Present study had significant difference ($p \leq 0.05$) in titratable acidity (TA) content in the segments. Decreasing trend in TA content was observed throughout storage study (Table. 1). However, by the end of the storage period TA content was higher in coated segments (1.13 %) than uncoated ones (1.00 %). Decline in TA content during storage study was due to the metabolic changes in fruit resulting from the use of organic acid during respiratory process (Kaur *et al.,* 2013) [27]. However, edible coating acts as barrier to water and gas exchange in the fruit. Thus, controlling metabolic changes whilst, maintaining organic acid by lowering respiratory process. Similar effects on titratable acidity were observed during storage of strawberry fruit (Sogvar *et al*., 2016) [13] by *Aloe vera* and ascorbic acid coating and Lin *et al*. (2008) [12] on 'Yali' pears with ascorbic acid and chitosan based-edible coating.

3.4 Total soluble solids (°brix)

In the present study total soluble solid (TSS) content remained

same in both coated and uncoated segment up to 6th days of storage, but at 9th day there found slight higher TSS content in coated segments (8.43 °brix) than uncoated ones (8.30 °brix). However, there was no significant difference among treatments at all stage of storage study (Table. 1). This was because, edible coating act as a semi-permeable membrane which lowers respiration rate by reducing formation and use of metabolites thus resulted in higher TSS content in coated segments. These results are on par with Sogvar *et al*. (2016) [13] and Lin *et al*. (2008) [12] study on strawberry and pear fruit respectively in which edible coating incorporated with ascorbic acid maintained TSS content along with cellulose based coating material.

3.5 Ascorbic acid (mg/100g)

Ascorbic acid is very unstable and is considered to be the most representative and bio-chemical indicator of nutritional value of fruits and vegetables (Canet and Alvarez, 2005) [28]. Present study showed significant difference ($p \leq 0.05$) between the segments. Decreasing trend in ascorbic acid content was observed in both coated and uncoated segments at all stages of storage study (Table. 1). However, by the end of the storage period ascorbic acid content was higher in coated segments (40.53 mg/100g) compared to uncoated ones (33.41 mg/100g). This was due to its activity and own antioxidant property. These results are in confirmation with the study of Sogvar *et al.* (2016) [13] in strawberry fruit with *Aloe vera* and ascorbic acid edible coating and Ayranci and Tunc (1997) [25] study on apricots and green pepper with methyl cellulose + polyethylene glycol + ascorbic acid edible coating.

3.6 Antioxidant activity (mg AAE/100g)

Present experiment showed decreasing trend in antioxidant activity of Pomelo segment (Table. 1). However at the end of storage study antioxidant activity retention was higher in coated segments (60.82 mg AAE/100g) compared to uncoated segments (59.79 mg AAE/100g). The reason for highest retention of antioxidant activity in coated segment was due to its inherent antioxidant property (Sogvar *et al.,* 2016) [13]. The antioxidant activity of gum arabic also contributed in maintaining antioxidant activity of the segment at all stages of storage study. Similar results were found in Ali *et al.* (2013) [8] study on tomato and Khaliq *et al.* (2016) [9] study on Mango fruit. They suggested gum arabic as a novel coating material in retention of antioxidant activity and extending shelf-life of fruits.

Table 1: Moisture, titratable acidity, total soluble solids, ascorbic acid and antioxidant activity of coated and control Pomelo segments in refrigerated storage (5 °C)

	Storage (days)	Control (uncoated)	Edible coated (GA + AA)
Moisture (%)	Fresh	87.81 ± 0.09^{ax}	87.29 ± 0.10^{ay}
	3	87.97 ± 0.11^{bx}	87.96 ± 0.09^{bx}
	6	88.29 ± 0.05^{cx}	88.02 ± 0.06^{by}
	9	88.38 ± 0.05^{cx}	88.13 ± 0.03^{cy}
Titratable acid (%)	Fresh	1.17 ± 0.00^{ax}	1.19 ± 0.05^{ay}
	3	1.13 ± 0.00^{bx}	1.16 ± 0.00^{by}
	6	1.13 ± 0.00^{bx}	$1.15 \pm 0.00b^{y}$
	9	1.00 ± 0.00^{cx}	$1.13 \pm 0.00b^{y}$
Total soluble solids (°brix)	Fresh	9.40 ± 0.00^{a}	9.40 ± 0.10^{a}
	3	9.30 ± 0.10^{a}	9.30 ± 0.10^{a}
	6	9.10 ± 0.10^{b}	9.10 ± 0.10^{b}
	9	8.30 ± 0.10^{c}	8.43 ± 0.10^{c}
Ascorbic acid (mg/100g)	Fresh	47.98 ± 0.00^{ax}	44.98 ± 0.00^{ay}
	3	41.86 ± 0.00^{bx}	42.83 ± 0.38^{by}
	6	35.88 ± 0.00^{cx}	40.54 ± 0.36^{cy}
	9	33.41 ± 0.37^{dx}	40.53 ± 0.00^{cy}
Antioxidant activity (mg AAE/100g)	Fresh	80.32 ± 10.65^{a}	77.40 ± 17.91^{a}
	3	73.72 ± 3.96^{a}	67.72 ± 1.36^{a}
	6	66.66 ± 9.47^{a}	65.32 ± 1.33^{a}
	9	59.79 ± 11.31^{a}	60.82 ± 7.62^{a}

Note: Values are mean of three replications, Different superscripts (a, b, c and d) within a column indicate significant differences due to storage time according to ANOVA test ($p \leq 0.05$). Different superscripts (x and y) within a row indicate significant differences among coating and control according to ANOVA test ($p \leq 0.05$). GA: gum arabic, AA: ascorbic acid.

3.7 Colour

In present investigation, change in colour of the segment was determined using munsell colour chart (Munsell, 1952) [21]. Results showed no fluctuation in colour of the segments throughout storage study. In the present study colour of segments was matched as 5.0 R (6/10) for all the coated and uncoated segments (Table. 2). Retention of colour may be due to the cells of segments which are by and large intact and chances of enzymes coming in contact with pigments were less. Therefore, degradation of colour is not an important feature in this fruit that is why it was observed that the colour as such did not change in both coated and uncoated segments. Addition to this, storing of segments in cold storage condition (5°C) also resulted in retention of colour. These results of cold storage effect on colour were on par with the study conducted by Ming-Jiang and Chen (1994[29]) on litchi fruit.

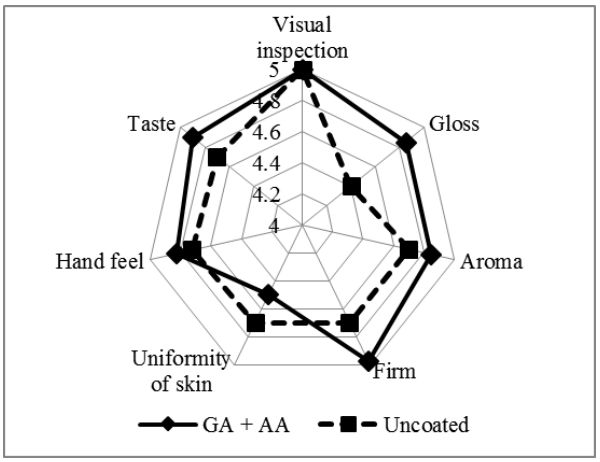
Table 2: Effect of storage on change in colour (H, V/C)* of coated and control Pomelo segments using munsell colour chart

Edible coatings	Storage (Days)			
	Fresh	3	6	9
GA + AA	5.0 R (6/10)	5.0 R 6/10)	5.0 R 6/10)	5.0 R 6/10)
Control (uncoated)	5.0 R (6/10)	5.0 R (6/10)	5.0 R (6/10)	5.0 R 6/10)

R- Red, *H (V/C) – Hue (Value/Chroma); GA- gum arabic; AA-ascorbic acid.

3.8 Sensory evaluation

Sensory evaluation of coated and uncoated (control) Pomelo segments during storage study revealed significant difference ($p \leq 0.05$) in glossiness, firmness and uniformity of the skin of segments. However, visual inspection, aroma, hand-feel and taste were not significantly different in the present study. There was no visual sign of decay in both coated and uncoated segments throughout storage study. This was due to effect of coating. Similar results of delayed visual decay were supported by Ali *et al*. (2010) [10] study on tomato fruit with gum arabic coating, who suggested that gum arabic coating leads to delayed senescence, which interns leads to delayed visual decay. At the end of the storage study firmness, hand-feel values were lower in uncoated segments than coated ones (Fig. 1). Similar results were found in Al-Juhaimi (2012) [11] study on firmness of tomato fruit with gum arabic coating. They suggested that retention of firmness and hand-feel were due to the effect of coating, which inhibits gas exchange between surface of the segments and environment. Thus, reduces the action of enzymes, allowing the retention of firmness and hand-feel during storage period. Also, glossiness, aroma and taste were better retained and accepted by sensory panellists in coated segments compared to uncoated ones. This was due to effect of edible coating with appropriate formulation of ascorbic acid (5%) during coating. Sogvar *et al*. (2016) [13] also supported 5% ascorbic acid formulation as ideal for coating on strawberry fruit, which found to maintain keeping quality throughout storage study.



Note: Values are means of ten replications, GA- gum arabica, AA- ascorbic acid.

Fig 1: Sensory scores of coated and uncoated Pomelo segments in refrigerated storage (5˚C).

3.9 Microbiological evaluation of coated segments

Present study showed significant difference ($p \leq 0.05$) in microbial population between coated and uncoated segments (Table. 3). At the end of the storage study total bacterial population was higher in uncoated (control) segments (21.60×10^3 CFU/g) compared to coated segments (17.93×10^3 CFU/g). But, mould population was completely nil in coated segments. However, uncoated segments had 0.06×10^3 CFU/g of mould population. This was due to antimicrobial effect of ascorbic acid. Similar results was supported by Tajkarimi and Ibrahim, (2011) [14] study on carrot juice, who found that ascorbic acid in combination with lactic acid has antimicrobial effect against *Listeria monocytogenes* and on *Escherichia coli*. Similarly, another study conducted by Sogvar *et al*. (2016) [13] proved that *Aloe vera* with 5 per cent ascorbic acid was effective in delaying changes in the ripening and reducing microbial population in strawberry fruit. In this study also, we found that gum arabic in combination with ascorbic acid had effective control over microbial growth in Pomelo segments during storage study at refrigerated condition (5˚C).

Table 3: Microbiological population of Pomelo segments in refrigerated storage (5 ˚C)

	Storage (days)	Control (uncoated)	Edible coated (GA + AA)
Total bacterial population ($\times 10^3$ CFU/g)	Fresh	9.00 ± 4.36^{ax}	1.53 ± 0.21^{ay}
	3	11.00 ± 2.00^{ax}	3.67 ± 0.58^{ay}
	6	14.26 ± 2.54^{ax}	14.53 ± 2.05^{bx}
	9	21.60 ± 4.20^{bx}	17.93 ± 6.33^{by}
Mould population ($\times 10^3$ CFU/g)	Fresh	3.33 ± 3.21^{ax}	0.10 ± 0.10^{ay}
	3	3.33 ± 0.57^{ax}	0.33 ± 0.58^{ay}
	6	0.06 ± 0.11^{bx}	0.00 ± 0.00^{ax}
	9	0.06 ± 0.11^{bx}	0.00 ± 0.00^{ax}

Note: Values are mean of three replications, Different superscripts (a and b) within a column indicate significant differences due to storage time according to ANOVA test ($p \leq 0.05$). Different superscripts (x and y) within a row indicate significant differences among coating and control according to ANOVA test ($p \leq 0.05$). GA: gum arabic, AA: ascorbic acid.

3.10 Effect of packaging condition on quality of Pomelo segments

Vacuum packaging is emerging as one of the important tool in maintaining quality and extending shelf-life of fresh-cut fruits, due to reduced oxygen level in a sealed package (Deepa and Chetti, 2013) [15]. Present study showed significant difference ($p \leq 0.05$) in moisture, TSS, antioxidant activity and ascorbic acid content between both coated and uncoated segment, except TA content (Fig. 2). Irrespective of coating; moisture content (Fig. 2A) was higher in vacuum packaging (89.30 %) compared to normal packaging (87.98 %). This was because; vacuum packaging inhibits or acts as barrier for absorption of atmospheric moisture into surface of segments. Similar results was reported by Pesis *et al.* (2005) [30] on vacuum packaging of ethylene pretreated banana, which reduced ripening process in banana, thus contributed to shelf-life extension. Titratable acidity (Fig. 2D) was slightly higher in normal packing (1.14

%) compared to vacuum packed segments (1.12 %). Decrease in titratable acidity might be due to the use of organic acid as respiratory substrate during storage study. These results are on par with study of Kaur *et al. (*2013) [27], on vacuum packed pear fruit. Present study showed higher total soluble solid content (Fig. 2C) in vacuum packaging (9.49 °brix) compared to normal packaging condition (9.03 °brix). Similar findings were presented by Kaur *et al. (*2013) [27] on vacuum packaging of pear fruit. They suggested that vacuum packaging leads to restriction of respiration rate in fruit, which intern reduces utilization of sugars and degradation of total soluble substances, thus leading to decreased TSS content. In the present study ascorbic acid (Fig. 2B) and antioxidant activity (Fig. 2E) were higher in vacuum packaging (50.80 mg/100g and 78.93 mg AAE/100g respectively) compared to normal packaging condition (40.1 mg/100g and 68.96 mg AAE/ 100g) this was because oxygen is not available for oxidation of ascorbic acid. These findings were supported by Howard and Hernandez (1997) [31] study on vacuum packaging of minimally processed jalapeno pepper rings. They reported that vacuum packaging was involved in inhibiting oxidative enzyme activity, which further enabled better retention of antioxidant activity throughout storage study.

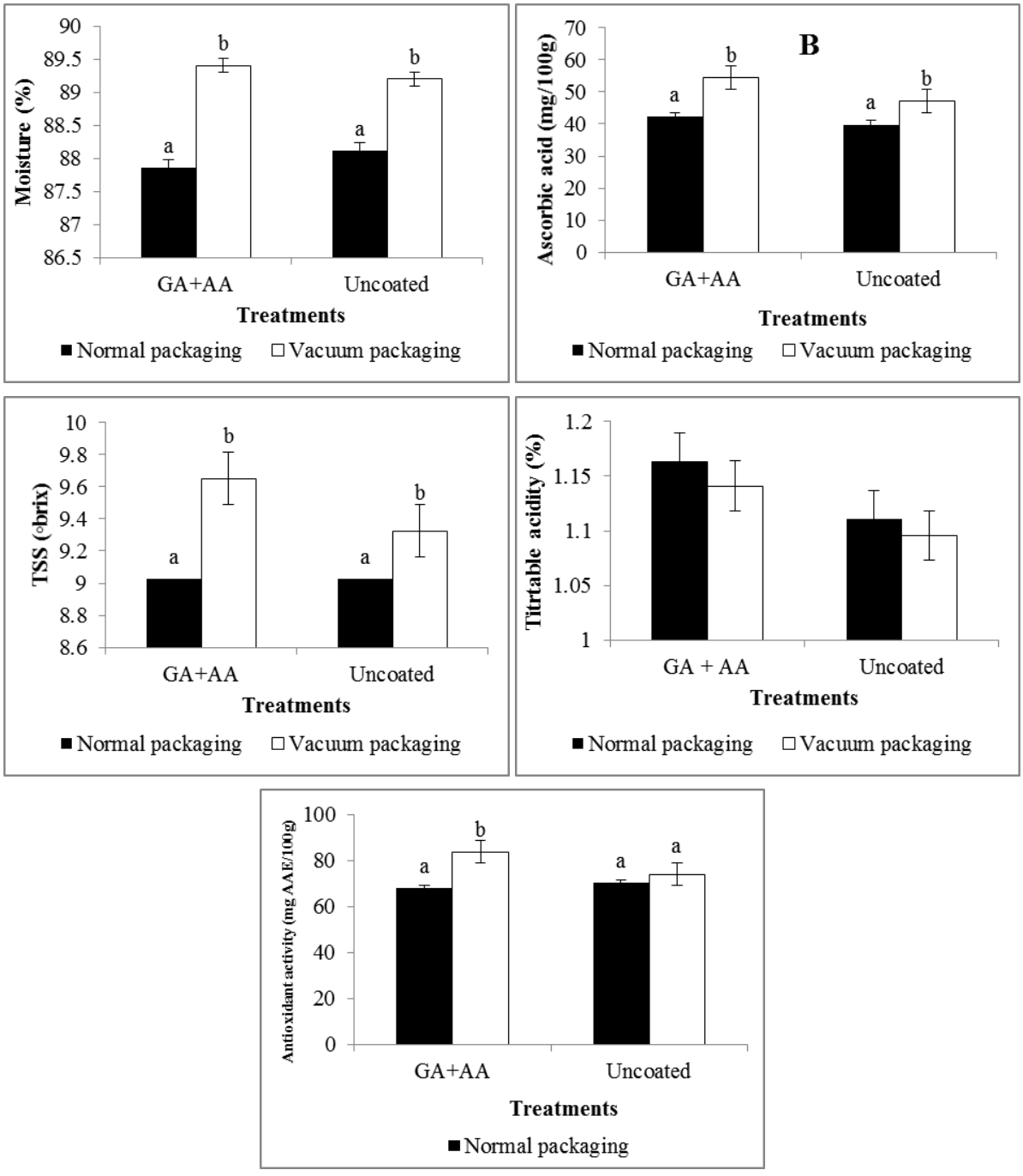


Fig 2: Effect of edible coating on A) Moisture content, B) Ascorbic acid, C) Total soluble solids, D) Titratable acidity, E) Antioxidant activity of Pomelo segments; GA- gum arabica, AA- Ascorbic acid.

4. Conclusion

Present study demonstrated that gum arabic (18%) based edible coating incorporated with 5 per cent ascorbic acid was effective in extending shelf-life of Pomelo segments by maintaining overall quality parameters of segments such as moisture, titratable acidity, total soluble solids, ascorbic acid, antioxidant activity and sensory attributes at refrigerated condition (5°C). Also 5 per cent ascorbic acid in edible coating was effective in reducing microbial growth in the segments. In addition to edible coating, combined effect of edible coating and vacuum packaging was found be effective technique in maintaining the quality of Pomelo segments throughout storage study.

5. Acknowledgement

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