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UV-C light and mild hot water for keeping overall quality of fresh-cut pomegranate arils

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Abstract. Manually extracted pomegranate arils (cv. 'Mollar de Elche'), chlorine disinfected (100 ppm), rinsed and drained arils (Control) were exposed to either 4.54 kJ m^{-2} ultraviolet-C light (UV-C) or immersed for 30 s in water at 55ºC (HW), packaged in polypropylene (PP) baskets (100 g), sealed on the top and then stored up to 14 days at 5ºC. The respiration rate (RR), atmosphere composition, titratable acidity (TA), total soluble solids content (TSS), microbial growth and sensory quality were monitored. Passive MAP composition at the steady state was the same (16 kPa O_2 + 5 kPa CO_2) independently of the treatment. RR tended to slightly increase during storage being in general slightly lower for the Control (between 1.5 and 1.7 ml CO_2 kg^{-1} h^{-1}). Significant changes were detected for TA which decreased from the initial value (0.19 g citric acid/100 ml) to 0.09, 0.08 and 0.1 g citric acid/100 ml for control, HW and UV-C respectively at the end of storage. From the initial TSS of 15.8ºB, a slight reduction in HW treatment was found. No noticeable changes in TSS for control and UV-C treatment were found. *Mesophilic* counts strongly decreased by HW and in a lesser extent by both UV-C and chlorinated water. The same trend was found for molds and yeasts. No *Enterobacteriaceae* growth was observed in any treatment. Control as well as all HW treated arils were sensory scored as poor, being qualified as unmarketable after 14 days. In contrast arils from UV-C kept well enough their sensory quality and were considered as good, being this treatment reliable for keeping overall quality and safety.

Keywords. *Punica granatum* L. – Ultraviolet – Hot water – Minimal processing – Modified atmosphere packaging – Respiration – Quality – Safety.

I – Introduction

Pomegranate is mainly consumed fresh and although their excellent healthy properties and quality attributes, difficulties in peeling to obtain the arils have limited its consumption. Production of minimally fresh processed or fresh-cut (FC) arils ready-to-eat may increase the consumption of pomegranates (Artés *et al.*, 1995). There is an increasing consumer demand to eliminate or reduce the use of agrochemicals on fresh products for extending their shelf life. One method has been the use of heat treatments for reducing postharvest decay in fruit and vegetables (Chan and Tian, 2005). However, no information is available on the use of mild hot water (HW) treatments on pomegranate arils. Another approach is the use of germicidal UV light at 200-280 nm (UV-C) for surface disinfection of FC commodities due to the lack of a residual compound on the surface of the produce and their low cost for the industry (Allende and Artés, 2003).

The objective of the current work was to evaluate the efficacy of HW and UV-C treatment in order to prolong the shelf-life and maintain the overall quality of FC pomegranate arils. From the best of our knowledge this kind of strategy on pomegranate arils is firstly reported here.

II – Material and methods

*Plant material***.** 'Mollar de Elche' fruits were supplied by Cambayas S.C. (Elche, Alicante), and after harvesting were transported 70 km to the Pilot Plant of Postharvest and Refrigeration Group in the Technical University of Cartagena. Arils were manually extracted in a disinfected cold room at 8ºC, washed in 100 µl l^{-1} NaOCl, acidified with citric acid (5%), and rinsed.

Treatments conditions. The treatments were as follows: arils left in a water bath set at 55ºC for 30s (HW); arils exposed to 4.54 kJ/m^2 UV-C (UV-C); arils without any treatment as Control. PP trays (about 100g arils each) were sealed on the top with a bioriented PP film and then stored at 5ºC and 95% RH up to 14 days. Analyses were made on days 0 (processing), 4, 8, 12 and 14.

Respiration rates and gas composition changes. For each treatment and day 3 replicates (100 g each) were placed within 750 ml glass jars at 5ºC for 14 days. The respiratory CO_2 and changes in O_2 and CO_2 levels within packages were monitored during shelf life by mean of a gas chromatograph, equipped with a thermal conductivity detector and Poropack-N 80/100 column.

Microbial analysis. Microbial analysis was performed as described in Aguayo *et al.* (2007). Mesophilic, *Enterobacteriaceae*, yeast and mould counts were reported as log cfu g^{-1}.

Total soluble solids content and titratable acidity. In arils juice TSS (°Brix) were determined by a refractometer at 20°C and TA (g of citric acid 100 ml^{-1}) in an automatic titrator by titrating with 0.1N NaOH of 10 ml diluted with 50 ml water, reaching pH 8.1.

Sensory evaluation. Ten members of an experienced sensory panel rated the arils, using a 5-point scale (1, dislike extremely 5, like extremely). Aroma, taste, firmness, visual appearance, color, browning and dehydration were evaluated (López-Rubira *et al.*, 2005).

III – Results

Gas composition and respiration rate. As expected the O_2 levels decreased and those of CO_2 increased within all packages during storage (Fig. 1). The RR was almost constant during shelf life in Control and treated arils, according to pomegranate is non-climacteric (Gil *et al.*, 1995). The increase in RR found at day 14 seems due to microbial growth, without differences between Control and UV-C and HW arils (Fig. 2.A). HW and UV-C didn't provoke any respiratory stress on FC arils in agreement with López-Rubira *et al.* (2005).

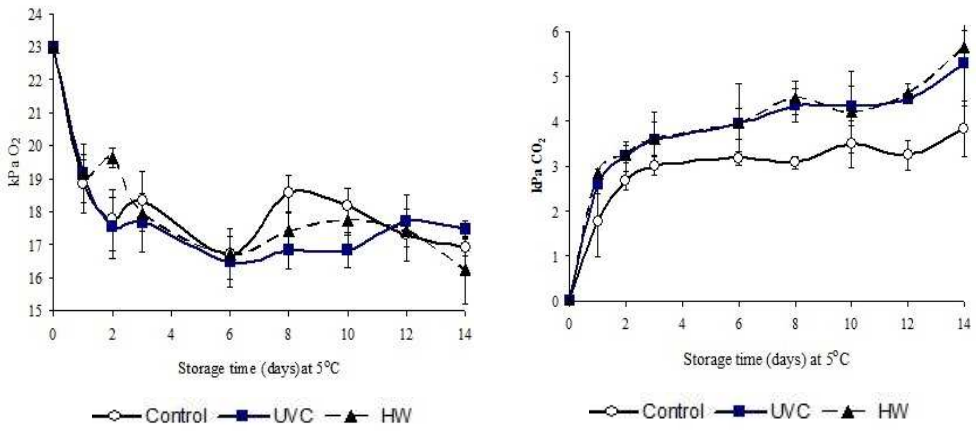

Fig. 1. Gas composition within packages of minimally processed arils during shelf life. Data represent means of three replicates (n=3 ± SD).

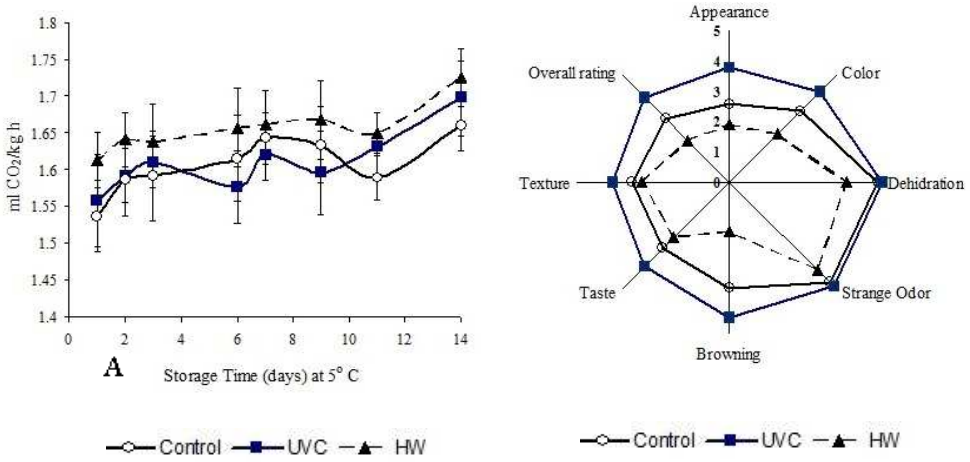

Fig. 2. (A) Respiration rate (ml CO_2/kg h) throughout 14 days at 5ºC in air of minimally fresh processed arils. Data represent means of three replicates (n=3 ± SD). (B) Sensory scores of fresh-cut arils stored up to 14 days at 5°C. Data represent means of 10 replicates (n = 10).

Microbial analysis. Throughout shelf life no *Enterobacteriaceae* growth (log cfu g^{-1}) on FC arils was found. Mesophilic counts yeast and mould were influenced by HW and UV-C (Table 1). Detrimental effect of the UV-C light and heat on the microorganism could directly retarded fungal spore germination and indirectly, can activate defense responses in fruit (Pan *et al.*, 2004).

Table 1. Shelf life Microbiological accounts in pomegranate arils under control, ultraviolet-C (UV-C) and hot water (HW) treatments. Values are mean log cfu g^{-1} (n=5 ± SD)

Bacteria	Days	Control	UVC	HW
Mesophilic (10Log cfu/g)	Initial	4.15b	4.15b	4.15b
	0	3.77±0.06d	3.25±0.046fg	2i
	7	3.9±0.04c	3.21±0.052fg	2i
	14	4.31±0.07a	3.49±0.08e	2.13±0.02h
Fungi	Days	Control	UVC	HW
Mould (10Log cfu/g)	Initial	3.17a	3.17a	3.17a
	0	2.85±0.06b	2.69±0.05b	2e
	7	3.2±0.09a	2.76±0.06b	2e
	14	3.28±0.14a	2.73±0.09b	2.24±0.05d
Yeast (10Log cfu/g)	Initial	3.85b	3.85b	3.85b
	0	3.11±0.03d	2k	2k
	7	3.81±0.03b	2.13±0.07j	2.21±0.04j
	14	4.03±0.06a	2.82±0.03g	2.93±0.01ef

Values within rows followed by different letters are significantly different according to Duncan's multiple range test at $p \leq 0.05$.

Total soluble solids content and titratable acidity. In comparison to initial values, at the end of the storage, practically no changes in TSS were detected in FC arils (except a slight reduction in HW treatments as well as slight increase in UV-C) (Table 2). However TA decreased in all treatments in a similar level (Table 2). This could be due to organic acids were predominant

substrates for respiratory activity of arils. These results confirm those of studies showing no remarkable TSS and TA changes in the same 'Mollar de Elche' cv (Gil *et al.*, 1995).

Table 2. Total soluble solids content (TSS, ºBrix), total titratable acidity (TA, g citric acid/100 ml) during shelf life for pomegranate arils under control, ultraviolet-C (UV-C) and hot water (HW) treatments. Values are mean (n=3) ± standard deviation

	Day	Control	UVC	HW
TSS (ºBrix)	0	15.8±0.05bc	15.8±0.02bc	15.8±0.04bc
	4	15.7±0.05c	15.8±0.05bc	15.2±0.03hij
	8	15.8±0.01bc	16±0.05a	15.1±0.05jk
	11	15.7±0.4c	15.6±0.03cd	15±0.04kl
	14	15.9±0.02ab	16±0.02a	15.3±0.05ghi
TA (g Citric acid/100 ml)	0	0.19a	0.19a	0.19a
	4	0.1±0.01cdefg	0.11±0.008bcdef	0.09fg
	8	0.09efg	0.09±0.003efg	0.11±0.01cdefg
	11	0.1defg	0.1±0.005defg	0.1±0.003cdefg
	14	0.09±0.006efg	0.1±0.003defg	0.08±0.003g

Values within rows followed by different letters are significantly different according to Duncan's multiple range test at $p \leq 0.05$.

Sensory evaluation. External visual appearance aroma, taste, firmness, visual appearance, colour, browning and dehydration, of UVC after 14 days of MAP storage at 5ºC were still acceptable for consumption. However, according to sensory test control arils as well as all HW treated arils were scored as poor, and consequently were unmarketable (Fig. 2B).

IV – Conclusions

UV-C treated arils showed lower mesophilic, yeast and mould counts and higher marketability than Control and HW. This treatment did not modify the SSC and TA, two key factors associated to fruit flavour and consumer's acceptance. Therefore, the use of UV-C seems to be justified for improving the shelf life of FC pomegranate arils in the current studied conditions.

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