Use of xanthan gum as edible coating to prolong shelf life of cactus pear fruit

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Abstract

The objective of this work was to elucidate the effect of xanthan gum-based edible coating $C_{35}H_{49}O_{29}$ on the quality of cactus pear fruit (*Opuntia ficus-indica*). The research was conducted in 2018, on *O. ficus-indica* 'Bianca' fruit, coming from second bloom "scozzolatura". After harvest, 100 fruits were coated with a xantan gum (XAN) and distilled water and on other 100 fruits were immersed in distilled water (CTR). All fruits were stored at 6±0.5°C with RH 90% for 30 days. Every 7 days, visual quality browning index score, flesh colour, total soluble solids (TSS), total acidity (TA), ascorbic acid and total phenols were measured. During cold storage, fruit treated with XAN ($p<0.05$) showed significant reduction of the oxidative browning of skin and an increase of total phenolics content then CTR fruit. The best results were shown after 14 days of storage on fruit treated with XAN rather than CTR for the following parameters: visual quality browning index score, flesh colour, total soluble solids (TSS) and total acidity (TA).

Keywords: ascorbic acid, browning, prickly pear, weight loss

INTRODUCTION

Cactus pear (*Opuntia ficus-indica*) originated from Mexico (Inglese et al., 2002) is a member of the *Cactaceae* family. The fruits are usually used for human consumption while the cladodes can be used in animal diets to increase the polyphenol content of milk (Valentini et al., 2018). *Opuntia ficus-indica* grows in Latin America, South Africa and in the Mediterranean area. In Italy, cactus pear is grown mainly in Sicily, which has a virtual monopoly on the crop and its marketing as a fresh fruit. The principal cultivars are called 'Rossa', 'Gialla' and 'Bianca' and are marketed from August to late December. The crop keeps ripening right up to the end of the year thanks to a specific management practice where first flowers are removed in spring so as to induce a second bloom in summer, this practice is called "scozzolatura" (Barbera et al., 1992).

Cactus pear is a good source of antioxidants because it is rich in polyphenols and betalaines (Khatabi et al., 2016). Sortino et al. (2019) used a treatment with 1-methylcyclopropene in cactus fruits to reduces the degradation of polyphenols and carotenoids during storage at 8°C. Cactus pear fruit is also important for the role of ascorbic acid during storage (Allegra et al., 2015). The amount of ascorbic acid is approximately 50-150 mg kg^{-1} FW.

According to Sortino et al. (2019), the shelf-life of 'Gialla' cactus pear fruit is short, around 30 days at 5°C and depends on maturity stage. Edible coatings are generally applied on fruit to prolong the shelf-life by dipping or spraying. The mucilage (Allegra et al., 2017) or gel of the *Aloe* leaf (Sortino et al., 2020) consists of approximately 99.5% water and 0.5% of solid material that includes compounds like polysaccharides, vitamins, phenolic compounds, and organic acids (Boudreau et., 2006).

Xanthan gum, synthesized as an exopolysaccharide by *Xanthomonas campestris* under unfavourable conditions, is a "Generally Recognized as Safe" (GRAS) compound (FDA, 21CFR172.695, 2013) for its use as a stabilizer, thickener or emulsifier. It forms a highly

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viscous solution in cold or hot water at low concentration with excellent stability over a wide range of pH and temperature and it is also resistant to enzymatic degradation.

Most recently, the effect of xanthan gum coating was studied on minimally processed cactus pear.

Therefore, the present investigation was carried out with the aim of evaluating the efficacy of xanthan gum (XAN) as an edible coating on the quality characteristics of cactus pear during storage at 6°C for 30 days.

MATERIALS AND METHODS

Plant material

The research was conducted in 2018, on *O. ficus indica* 'Bianca', fruit, coming from the first and the second bloom induced by the "scozzolatura". The former was harvested, October 16, 2018, from 10 trees grown in a commercial orchard located in Roccapalumba, Sicily, Italy.

Treatments

Two-hundred fruits were then sanitized by immersion in 200 mg kg^{-1} of sodium hypochlorite for 5 min and left to dry at room temperature (20°C). The treatments used for coating of cactus pear fruit are 1) CTR: control, and 2) XAN (2.5 g L^{-1} xanthan gum). The solution was prepared by mixing 2.5 g xanthan gum powder with 1 L of autoclaved distilled water at 50°C under magnetic stirring.

One hundred and 50 single bag replicates per treatment were packed in polyethylene terephthalate (PET) with macro-perforated packages film. Packages were stored at 6°C and 90% RH for 30 days.

Quality measurements

Weight of individual fruit was recorded immediately after harvest (day 0) and at the different sampling dates (7-, 14-, 21- and 30-days during storage). TSS was determined with a hand-held refractometer. Total phenolic content of the juice was determined according to Georgé et al. (2005); gallic acid was used as a reference standard and the results were expressed as mg gallic acid equivalent (mg GAE L^{-1}) of juice.

The methanolic extract was prepared from each sample by homogenizing 5 g of cactus pear tissue in 50 mL of methanol using a mortar and pestle. The homogenate was kept overnight at 4°C and on the second day it was centrifuged at 10621 rpm for 15 min at 4°C.

The Folin-Ciocalteu method was used to determine the total phenolic content. At each sample date, six fruits were analysed. Gallic acid was used as a standard to produce the calibration curve.

Estimation of ascorbic acid was performed as described by Allegra et al. (2017), and the concentration of ascorbic acid was expressed in g of ascorbic acid kg^{-1} of fresh weight.

The overall appearance (visual quality) was determined on 12 single fruit replicates for each sample date (0, 7, 14, 21 and 30 d after packaging) by six untrained panelists (three men and three women) based on the following scale: 5 = very good, 4 = good, 3 = fair (limit of marketability), 2 = poor (limit of usability) and 1 = very poor (inedible). Panelists were asked to give a visual quality score according to flesh colour changes and brightness, presence of mould, evidence of any apparent flaws on the surface area (Allegra et al., 2015).

Crunchiness was determined on 12 single fruit replicates at each sample date (0, 7, 14, 21 and 30 d after packaging) by six (three men and three women) untrained panelists based on resistance to chewing and using the following scale: 5 = very crunchy; 4 = crunchy, 3 = limit of marketability, 2 = soft and 1 = crummy inedible. Each panelist received and judged two single fruit replicates, each of them cut in two halves.

Browning index was determined on 12 single fruit replicates at each sample date (0, 7, 14, 21 and 30 d after packaging) by six (three men and three women) untrained panelists based on browning colour and using the following scale: 5 = none browning; 4 = minor browning, 3 = medium browning, 2 = browning and 1 = high browning. Each panelist received and judged two single fruit replicates, each of them cut in two halves. Samples were presented in a white plastic plate and tasted 1 h after they were taken out of the cold room (Sortino et al., 2017).

Statistical analysis

Statistical analysis was performed using ANOVA and Fisher's least significant difference test was applied to determine differences at a significance level of $p \leq 0.05$. Systat 13.0 software was used.

RESULTS AND DISCUSSION

The evolution of TSS during 30 days of storage at 6°C underwent a significant variation in the control (CTR) from 12.1 to 14.2% than to (XAN) treatment and at the 30th day, TSS reached an average value of 13.5%. Probably, the increase in TSS is linked to a reduction of water in cells due to the respiration and transpiration of the fruit. On the contrary, the fruit samples treated with xantan gum had a less reduction of weight loss (%) and for this reason the TSS content does not increase significantly until day 21 of cold storage. Titratable acidity (TA) reduced only after 21 days of storage in CTR fruit while there were no changes in fruit with XAN treatment (Table 1).

Table 1. Evolution of TSS (% soluble), weight loss (%) and TA (% citric acid) parameters of *Opuntia ficus-indica* during storage (7, 14, 21, and 30 days) at 6°C. Different letters indicate significant difference between CTR and XAN treatments. Data are means ± SEM (*n*=6).

Time of storage	TSS (% soluble) solids) (%)		Weight loss (%)		TA (% citric acid)	
(days)	CTR	XAN	CTR	XAN	CTR	XAN
0	12.1 ns	12.1	3.3 ns	2.3	0.06 ns	0.06
7	12.5 ns	12.3	4.4 ns	3.5	0.05 ns	0.05
14	12.8 ns	12.4	5.6 ns	5.1	0.05 ns	0.05
21	14.0 a	12.8 b	7.2 a	5.9 b	0.03 a	0.05 b
30	14.2 ns	13.5	9.4 a	7.2 b	0.03 ns	0.04

Cactus pear fruit peels contain higher amounts of phenolics, since phenolics tend to accumulate in the dermal tissues of plant bodies because of their potential role in protection against UV radiation (De Wit et al., 2020). Significant differences were observed in the content of polyphenols, which decreased ($P<0.05$) up to 21 days of storage in the control samples (Figure 1) while after 14 days, XAN treatment samples showed more significant differences than the CTR cactus pear fruit.

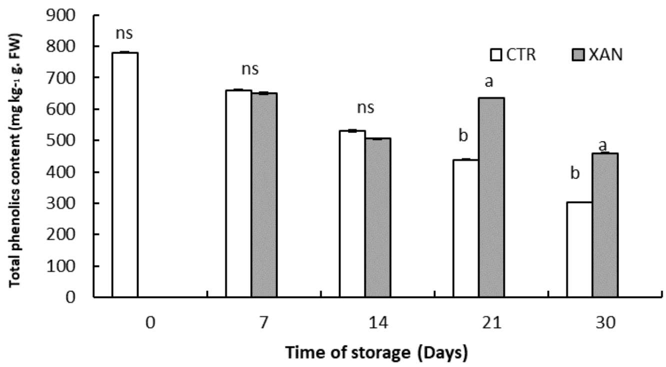

Figure 1. Total phenolic content of pulp of *Opuntia ficus-indica* fruit harvested and processed at commercially ripe (CR) and stored for 7, 14, 21, and 30 days at 6°C. Different letters indicate significant difference between CTR and XAN treatments. Data are means ± SEM (*n*=6).

The ascorbic acid content in cactus pear fruits is notably higher than the average ascorbic acid content in regularly consumed fruits (Gil et al., 2002). Being an important nutritional antioxidant, it is worth pointing out that in our work, ascorbic acid content, decreased significantly during storage in CTR and XAN treatments. Nevertheless, the value of ascorbic acid content, showed significant differences between CTR and XAN treatments, after 14 days of storage (Figure 2) where, although decreasing, the ascorbic acid content-maintained values above the control and still acceptable. Probably edible coating protected the fruit from oxidation, mainly by reducing the gas exchange between the atmosphere and fruit.

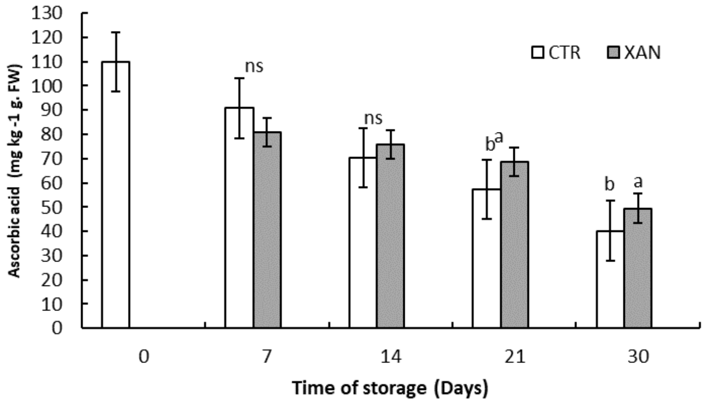

Figure 2. L-Ascorbic acid content of pulp of *Opuntia ficus-indica* fruit harvested and processed at commercially ripe (CR) and stored for 7, 14, 21, and 30 days at 6°C. Different letters indicate significant difference between CTR and XAN treatments. Data are means ± SEM (*n*=6).

Our results of hedonic analysis showed that the effect of XAN treatment preserved visual quality and reduced browning during storage a 6°C for 21 days. Figure 3 shows a significant reduction in the judges' visual quality scores during storage, but when comparing the values between treatments, there were significant differences at 7th and 21st day of storage.

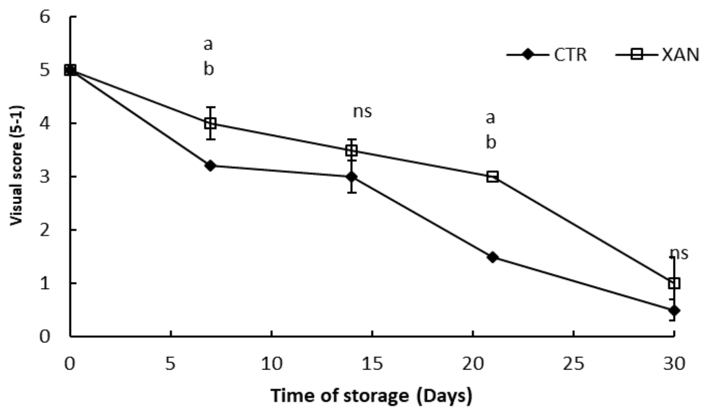

Figure 3. Visual quality score of *Opuntia ficus-indica* fruit harvested and processed at commercially ripe and stored for 7, 14, 21, and 30 days at 6°C. Different letters indicate significant difference between CTR and XAN treatments. Data are means ± SEM (*n*=6).

The same trend was shown by the browning index (Figure 4) detecting the colour change during storage. In this case, the judges' evaluations showed a significant difference between the CTR and XAN treatments at 21st day of cold storage.

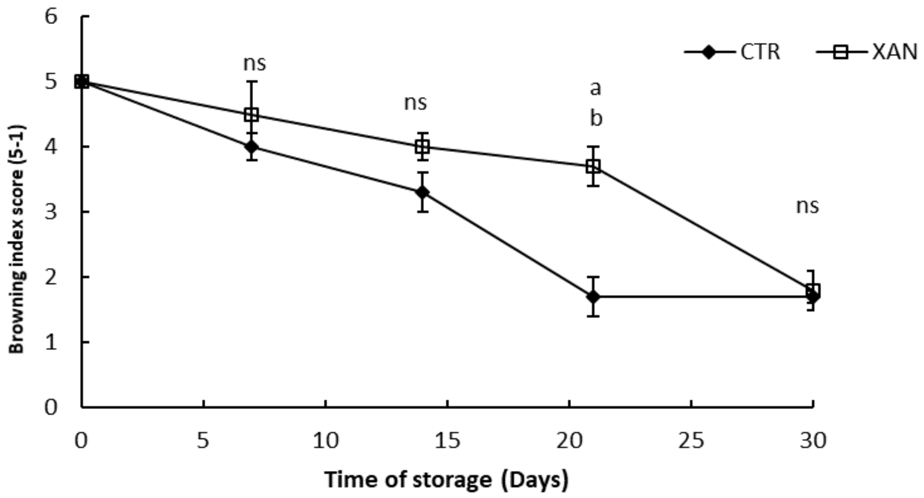

Figure 4. Browning index score of *Opuntia ficus-indica* fruit harvested and processed at commercially ripe and stored for 7, 14, 21, or 30 days at 6°C. Different letters indicate significant difference between CTR and XAN treatments. Data are means ± SEM (*n*=6).

During 30 days of cold storage, cactus pear fruit treated with or without edible coating (CTR and XAN) had significant reduction in flesh firmness. Figure 5 shows how the judges gave lower scores according to storage time. No significant difference was found between the treatments.

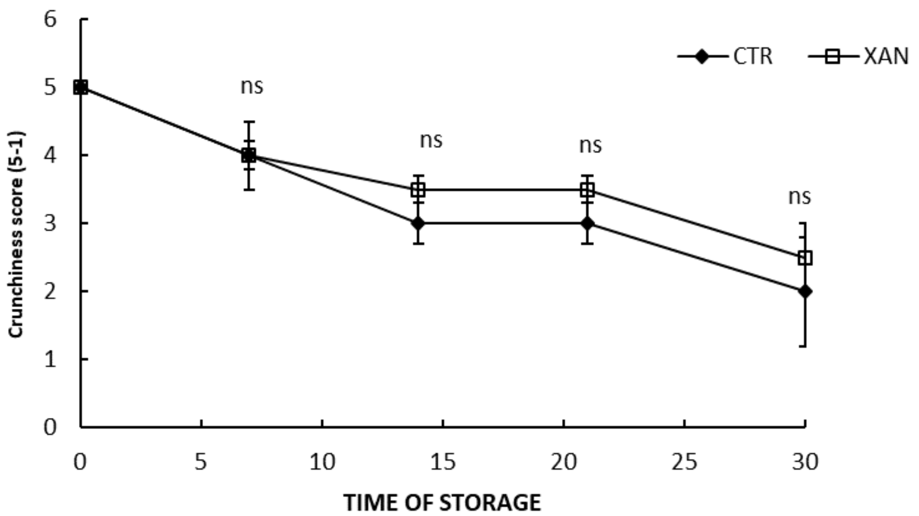

Figure 5. Crunchiness score of *Opuntia ficus-indica* fruit harvested and processed at commercially ripe and stored for 7, 14, 21, and 30 days at 6°C. Different letters indicate significant difference between CTR and XAN treatments. Data are means ± SEM (*n*=6).

CONCLUSIONS

The application of xanthan coating inhibited the change of colour; therefore, it prevented total phenolic oxidation, delayed browning incidence and extended the shelf-life up to 21 days of the storage period. Furthermore, the XAN treatment maintained the harvest values of TSS and TA after 21 days of storage better than the CTR. Further studies are needed to establish the efficacy of xanthan gum for the quality improvement of other fresh fruits and fresh-cut products.

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