# PACKAGING OF PLA
# FOR MINIMALLY PROCESSED CARROTS

**A. ZAPPIA, A. DE BRUNO and A. PISCOPO***
University Mediterranea of Reggio Calabria, Department of AGRARIA
*Corresponding author: amalia.piscopo@unirc.it

## ABSTRACT

Qualitative characteristics of minimally processed carrots packaged in PLA film were monitored at 4°C and 7°C up to verify a possible shelf life extension respect to the commercial one, attested at 7 days packaged in PP pouches. Acids stabilized the colour of cut carrots and reduced the total microbial growth up to 14 days. The best results were obtained in carrots treated with the highest citric acid % at 4°C. Acidic dipping contributed to extend the shelf life of minimally processed carrots. Moreover, PLA can be used as packaging material for carrots, as option to conventional plastics.

*Keywords*: carrots, citric acid, dipping, PLA

## 1. INTRODUCTION

Due to concerns about the environmental impact and health, consumers are avoiding the use of petroleum-based conventional packaging, which takes hundreds of years to decompose, and food products containing synthetic additives or preservatives (NAMPOOTHIRI *et al*., 2010). One of the most promising bio-based polyesters aimed for food packaging is polylactic acid (PLA) (PANSERI *et al*., 2018), a biopolymer chemically synthesized using monomers obtained from agro-resources like wheat, corn, and cassava. At the moment, PLA is one of the most used bio-polyesters due to its availability on the market, its low price and its mechanical and barrier properties (AVÉROUS, 2008; BORDES *et al*., 2009). Considering that PLA is also classified as GRAS (Generally Recognized As Safe) by the American Food and Drug Administration (FDA) and it is authorised by the European Commission (Commission Regulation No 10/2011), this polymer might be used in contact with food (BISHAI *et al*., 2014). Moreover, the use of some methods for sanitize the minimally processed vegetables is questioned since it has been shown that the habitual use of chlorine in the industries involves the formation of halogenated by-products, correlated to environmental and health risks in processing areas. Other typologies of agents have to be then considered that can be show multiple effect: sanitizing and inhibitor of oxidative and enzymatic reactions. In particular, among minimally processed vegetables, carrots often manifest a characteristic defect: the discolouration (also named whitening), due to the enzymatic reactions, which follow the cut of tissues. In a recent research the quality maintenance of carrots packed in conventional plastic material was supported by the dipping in acidic solutions that reduced the visual deterioration and slowed down the microbial growth during the storage (PISCOPO *et al*., 2019a). Different studies were conducted on the evaluation of the packaging with PLA for different food matrixes: orange juice (HAUGAARD *et al*., 2002), cheese (HOLM *et al*., 2006; PISCOPO *et al*., 2019b), yoghurt (FREDERIKSEN *et al*., 2003), spinach (BOTONDI *et al*., 2015) but on minimally processed carrots it has not been yet considered. The aim of this work was to test the PLA as packaging material for minimally processed carrots treated with acidic dipping as healthy alternative to chlorine.

## 2. MATERIAL AND METHODS

Minimally processed carrots were produced in a farm located in Calabria. To sanitize the shredded carrots, the farm applied the dipping in chlorinated water (300 mg $L^{-1}$) and packaged the carrots in Polypropilene (PP) microforated pouches at normal atmosphere. Two acidic solutions were used as dipping alternative to chlorine: 1% (B) and 1.5% citric acid (C), in comparison to a control in tap water (A). After dipping, carrots were centrifuged for 2' and packed in BoPLA pouches (NATIVIA ® NTSS, 25 cm x 20 cm of size; 30 µm of thickness; OTR: 730 $cm^3$ $m^{-2}$ 24 $h^{-1}$ $atm^{-1}$; WVTR: 270 g $m^{-2}$ 24 $h^{-1}$) at normal atmosphere and stored at 4°C and 7°C. The principal qualitative analyses were monitored up to 14 days to verify a possible shelf life extension respect to the commercial one, attested at 7 days. Total bacterial count of carrot aqueous extract was measured on PCA Plant Count Agar- growth land (Oxoid) at 26°C for 48 h and expressed as Log Colony Forming Units $g^{-1}$ (Log CFU $g^{-1}$). Colour measurement was monitored in each carrot sample (15 replicates) using a tristimulus colorimeter (model CM-700d, Konica Minolta, Osaka, Japan) calibrated with a standard white plate with reference to CIELab colour space. Results were expressed as whitening index score (WI) according to the formula (BOLIN and HUXSOLL 1991): $WI= 100 - [(100-L^{*2}) + a^{*2} + b^{*2}]^{0.5}$. AOAC methods (1980, 2000) were performed for measurements of the pH extracts (pH meter Crison GLP, Barcelona, Spain) and the titratable acidity, expressed as % of citric acid. Dry matter (% d.m.) was evaluated by loss weight in an oven at 70°C until a constant weight was reached.

## 3. RESULTS AND CONCLUSIONS

In Table 1 the results of total microbial charge of carrots packed in PP pouches are reported, indicating a shelf life of 7 days at both storage temperatures. The initial count of 4.9 Log CFU $g^{-1}$ tended to increase with high significance ($p$<0.01) to 6.7 and 6.8 Log CFU $g^{-1}$ (inside the safety threshold of 7 Log CFU $g^{-1}$).

**Table 1.** TBC on minimally processed carrots dipped in chlorine during storage at two temperatures (PISCOPO *et al.*, 2019).

| Temperature/Days | 1 | 3 | 7 | Sign. |
|---|---|---|---|---|
| 4°C | 4,91c | 5,97b | 6,70a | ** |
| 7°C | 4,91c | 6,21b | 6,88a | ** |

** Significance at P < 0.01.

Carrots dipped in acidic solutions manifested lower total microbial charge than the control samples during the storage at 4°C (Fig. 1a).

a

b

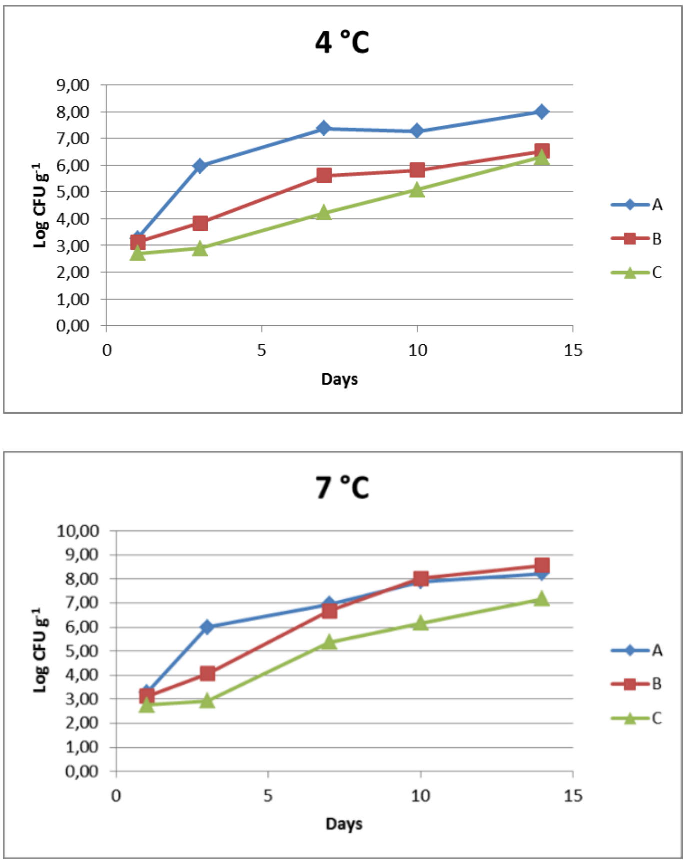


**Figure 1.** Total Bacterial Count during storage at 4°C (a) and 7°C (b).

At the end of monitoring both the treated samples were similar for microbial count (inside the safety threshold of 7 Log Colony Forming Units $g^{-1}$). In particular, the 1.5% citric acid dipping was the most effective to 10 days at both temperatures. These results were confirmed by pH and total acidity determinations (Table 2).

**Table 2.** Titratable acidity (TA), pH and dry matter of carrot samples during storage at two temperatures.

| | | Samples/days | 1 | 3 | 7 | 10 | 14 | Sign. |
|---|---|---|---|---|---|---|---|---|
| | | A | 0,07a | 0,04ab | 0,03b | 0,06ab | 0,05ab | * |
| | TA (g% citric acid) | B | 0,22a | 0,13b | 0,10b | 0,13b | 0,10b | ** |
| | | C | 0,35a | 0,24b | 0,19c | 0,26b | 0,17c | ** |
| | | A | 6,46c | 6,48c | 6,74a | 6,55bc | 6,65ab | ** |
| 4 °C | pH | B | 4,92d | 5,08c | 5,38ab | 5,35b | 5,53a | ** |
| | | C | 4,28d | 4,63c | 4,89ab | 4,77bc | 5,01a | ** |
| | | A | 9,32 | 8,70 | 9,67 | 10,30 | 8,64 | n.s. |
| | d.m. (%) | B | 8,87ab | 8,47b | 9,13ab | 10,03a | 8,47b | * |
| | | C | 9,39ab | 8,34b | 9,11b | 11,13a | 8,25b | ** |
| | | A | 0,07a | 0,05b | 0,05b | 0,04c | 0,03c | ** |
| | TA (g% citric acid) | B | 0,22a | 0,25a | 0,09b | 0,14b | 0,13b | ** |
| | | C | 0,35a | 0,12d | 0,18c | 0,26b | 0,17c | ** |
| | | A | 6,46b | 6,53b | 6,78a | 6,78a | 6,58b | ** |
| 7 °C | pH | B | 4,92d | 5,19c | 5,63a | 5,52ab | 5,40b | ** |
| | | C | 4,28d | 5,18a | 4,97bc | 4,79c | 5,09ab | ** |
| | | A | 9,32 | 9,00 | 9,30 | 9,75 | 7,91 | n.s. |
| | d.m. (%) | B | 8,87ab | 9,17ab | 8,73b | 9,80a | 8,35b | * |
| | | C | 9,39ab | 8,28b | 8,93ab | 11,11a | 8,31b | * |

Results are presented as the mean value ± standard deviation (n=2). ** Significance at P < 0.05.
* Significance at P<0.01; n.s. not significant.

At higher storage temperature only the carrots dipped in 1,5% of citric acid controlled the microbial growth, allowing to extend their shelf life to 14 days (Fig. 1b). The colour parameters did not significantly ($p$<0.05) change during the storage, as illustrated in Fig. 2 by Whitening index, showing that the two tested concentrations of citric acid can stabilize the colour of carrots and do not involve further discolouration. This event could be possible when the treatment is not efficient for the vegetables and does not stop the lignin formation by enzymatic activity, as just observed for a mixed solution (ascorbic and citric acid) in a previous study (PISCOPO *et al.*, 2019). In conclusions, PLA proved to be a valid packaging material for minimally processed carrots and it can be considered an alternative and eco-friendly proposal for the food industry. The successful use of acids in this experimentation can propose an option to chlorine in the carrot washing step. The tested concentrations of citric acids for the carrot washing step, in fact, in combination to the packaging in PLA, allowed to extend the commercial shelf life from 7 to 14 days at 4°C. At 7°C only the dipping in 1.5% citric acid maintained the quality of carrots up to 14 days. These results can be proposed to the food industry as a healthy and simple operations to produce ready to eat carrots of good quality.

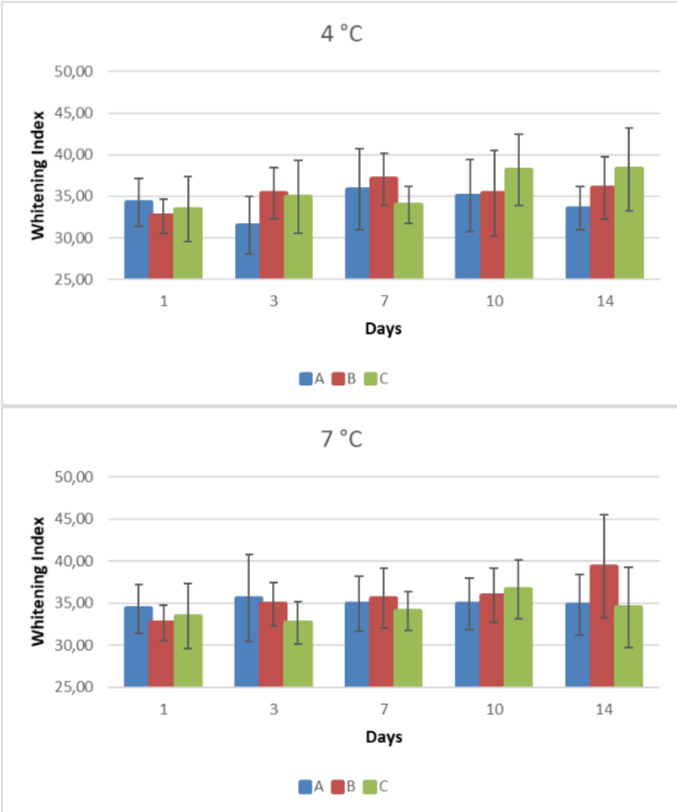


**Figure 2.** Whitening index during storage at two temperatures.

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