Quality and stability of frozen carrots fortified with green tea polyphenols

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INTRODUCTION

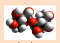
Green tea (GT) is a high source of polyphenols such as epigallocatechin gallate, epigallocatetich, epicatechin gallate, and epicatechin. Beside their antioxidant properties, these polyphenols show pharmacological activities and their consumption has been correlated with low incidence of chronic pathologies related to oxidative stress. The GT amount that must be consumed daily to obtain the aforementioned health benefits is quite high and difficult to achieve. In this contest, the production of food products fortified with GT extract (GTE) can help to reach the intake of GT polyphenols capable of exerting beneficial effects on human health. Nutritional fortification with GT extract was studied in bakery products such as bread and biscuits, noodles, probiotic yogurt, frozen surimi gel, in dried and minimally processed apples (Tappi et al., 2017). However, the addition of GTE to food products can affect their physical and sensory characteristics (e.g. colour) thus, the enrichment with GT can not be assessed only depending on the desired polyphenols fortification degree but it must be performed taking into account side effects exerted by these components on the quality attributes of the food product.

AIM:

To investigate the use of green tea extract for the production of frozen carrots fortified with GT polyphenols. In order to limit quality loss induced by processing and frozen storage and to produce high quality frozen products, carrots were enriched also with trehalose. The solutes penetration into the vegetable was performed by using, as freezing pre-treatments, blanching in combination with vacuum impregnation.

Green tea

high content in epigallocatechins ➔ beneficial effects on human health (diabetes, obesity, cancer, cardiovascular and microbial diseases prevention, antihypertensive and hypolipidemic effect)



Trehalose

protection of biological structures upon thermal stresses

M&M

- MATERIALS: Organic carrots (Daucus carota L., cv Romance) were selected (i.e. length of 18-20 cm and diameter of 1.5-2 cm), washed, peeled and cut in 0.5 cm thick slices. Green tea (Camelia sinensis) powder extract (GTE) was purchased from PromoPharma s.r.l. (Republic of San Marino) while trehalose from Adea s.r.l. (Busto Arsizio, Italy).
- SAMPLES PREPARATIONS: Carrot slices were blanched in water (BL_w) or trehalose 4% w/v (BL_{4T}) at 90 °C for 108 sec. Vacuum impregnation was carried out on BL_w or BL_{4T} samples by using as impregnant agent water (VI_w), trehalose 10% w/v (VI_{10T}), green tea extract 0.25% w/v (VI_E) or trehalose 10% w/v in combination with green tea extract 0.25% w/v (VI_{10T-E}). After pre-treatments, samples were packed in BOPP bags (film thickness: 30 mm) in air, frozen at -40 °C and stored at -18 °C up to 60 days.

- EVALUATIONS: mass transfers, trehalose content, colour (h°), firmness, residual peroxidase activity, total carotenoid content, total polyphenols content (TPC) by FC assay, antioxidant activity (AOA) by ABTS assay.
- STATISTICAL ANALYSIS: data were reported as mean and standard deviation and additionally analysed by ANOVA. Significant differences between means were calculated by LSD test at a significance level ≤ 0.05. Data were processed using the STATISTICA for Windows (Stat Soft™, Tulsa, OK) software.

	BLANCHING (BL)		VACCUM IMPREGNATION (VI)		
Samples	WATER (W)	TREHALOSE 4% w/v (4T)	WATER (W)	TREHALOSE 10% w/v (10T)	GREEN TEA EXTRAXCT 0,25% w/v (E)
F					
BL_W	✓				
BL_{4T}		✓			
$BL_{W+}VI_W$	✓		✓		
$BL_{4T}+VI_W$		✓	✓		
BL_W+VI_{10T}	✓			✓	
$BL_{W+}VI_E$	✓				✓
BL_W+VI_{10T-E}	✓			✓	✓
$BL_{4T}+VI_{10T}$		✓		✓	
$BL_{4T}+VI_E$		✓			✓
$BL_{4T}+VI_{10T-E}$		✓		✓	✓

Table 1: experimental plan.

RESULTS

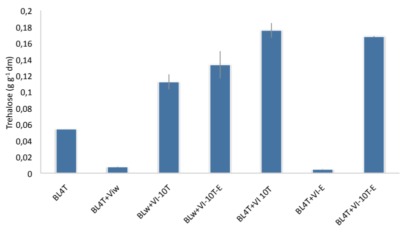


Fig I. Trehalose content after blanching and VI pre-treatments.

TREHALOSE ENRICHMENT

- Both blanching and vacuum impregnation pre-treatment allowed to effectively enrich the sliced carrots with trehalose.

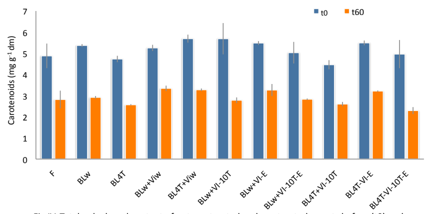
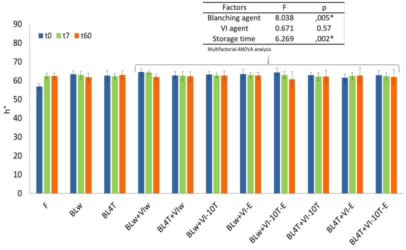


Fig IV. Total polyphenol content of not pre-treated and pre-treated carrots before (t0) and after freezing and frozen storage for 60 (t60) days.

CAROTENOIDS

- No differences in total carotenoids were observed among fresh and pre-treated samples.
- After freezing and frozen storage a significant decrease of carrots' carotenoid content was evidenced.



Factors	F	p
Blanching agent	8.038	,005*
VI agent	0.671	0.57
Storage time	6.269	,002*

Multifactorial ANOVA analysis

Fig II. Hue angle (h°) of fresh and pre-treated carrots before (t0) and after freezing and frozen storage for 7 (t7) and 60 (t60) days.

COLOUR

- BL and VI pre-treatments determined a slight increase in the h°.
- After freezing and frozen storage blanching in trehalose solution positively affected the hue angle of sliced carrots.

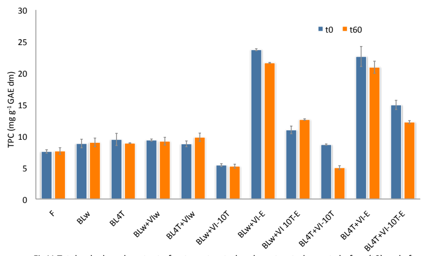
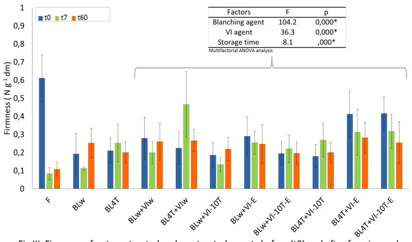


Fig V. Total polyphenol content of not pre-treated and pre-treated carrots before (t0) and after freezing and frozen storage for 60 (t60) days.

TOTAL POLYPHENOL CONTENT

- VI treatment in GT solutions determined a significant increase in polyphenols, which resulted three times higher than in the fresh vegetable. The addition of trehalose to GTE solution negatively affected the carrots fortification with these bioactive compounds.
- After freezing and 60 days of frozen storage, only samples blanched and vacuum impregnated with GTE solution evidenced a significant decrease of the TPC.



Factors	F	p
Blanching agent	104.2	0,000*
VI agent	36.3	0,000*
Storage time	8.1	,000*

Multifactorial ANOVA analysis

Fig III. Firmness of not pre-treated and pre-treated carrots before (t0) and after freezing and frozen storage for 7 (t7) and 60 (t60) days.

FIRMNESS

- Blanching significantly impaired the carrots' firmness. $BL_{4T}+VI_E$ and $BL_{4T}+VI_{10T-E}$ samples evidenced a higher firmness compared to the other pre-treated samples.
- Freezing and frozen storage negatively affected the carrots' firmness.
- All the samples blanched in trehalose solution showed after 7 days of frozen storage a higher firmness than the water blanched ones; however, after 60 days, no differences were found among samples.

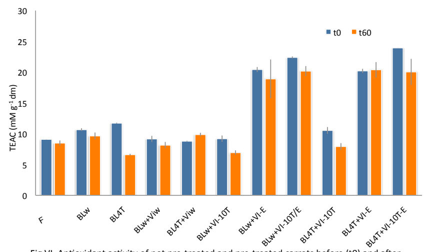


Fig VI. Antioxidant activity of not pre-treated and pre-treated carrots before (t0) and after freezing and frozen storage for 60 (t60) days.

ANTIOXIDANT ACTIVITY

- Blanching in trehalose solution and VI with GTE solution positively affected the carrots AOA;
- After freezing and frozen storage a significant AOA reduction was observed as an effect of both the carotenoids and polyphenols decrease.

CONCLUSION

- Blanching in trehalose solution and VI treatment with green tea extract slightly affected the quality properties of the carrots and allowed to increase considerably the carrots' functional properties and to preserve the firmness of the plant tissue.
- Trehalose showed a cryoprotective effect on the physical properties of the frozen samples only when its addition occurred by blanching.
- After freezing and frozen storage all the samples evidenced a significant loss of carotenoids while the total polyphenol content decreased only on carrots previously fortified with green tea polyphenols. Despite these variations, blanching and vacuum impregnation in green tea extract allowed to obtain after 60 days of frozen storage carrots with an antioxidant activity doubled compared to the fresh vegetable.

REFERENCES

Tappi, S., Tylewicz, U., Romani, S., Dalla Rosa, M., Rizzi, F., & Rocculi, P. (2017). Study on the quality and stability of minimally processed apples impregnated with green tea polyphenols during storage. Innovative Food Science and Emerging Technologies, 39, 148–155. https://doi.org/10.1016/j.ifset.2016.12.007.

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