28th Workshop on the Developments in the Italian Ph.D research on Food Science, Technology and Biotechnology

Catania, 18-20 September 2024

INNOVATIVE TECHNOLOGIES AND PROCESSES FOR SUSTAINABLE FROZEN FOODS

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Demand for frozen food products is increasing

HOWEVER →

Frozen food industry criticized for its:
- High carbon food print
- Green House Gas emission
- High energy consumption

SOLUTION →

Sustainable innovative technologies with low environmental impact.

→

Solar-powered freezing System
- Environmentally Friendly
- Energy Independence
- Long term cost effective

HOWEVER →

Fluctuating Temperatures

AIM

This Ph.D. project investigates the effect of innovative freezing technologies and eco-friendly freezing and frozen storage systems on the quality of food products.

MATERIALS & METHODS

D: 2±0.5 cm
Thickness: 0.5 cm

Pre-treatment: Blanching, 90℃ 3 min **(BL)**

Control: No pre-treatment **(NT)**

→ Freezing and Frozen Storage

Storage Temperature
- -20 ℃
- -30 ℃
- -40 ℃

$T'g_{carrot}$= -38.18±0.6 ℃

→ Conventional Freezers **(CF)**

→ Solar-powered freezers **(SPF)**

The following analyses were carried out: temperature monitoring freezing cells, residual activity of peroxidase (POD) and pectin methylesterase (PME) according to Neri et al. (2011); moisture content, color (spectrophotocolorimeter, CIElab), mechanical properties (Instron Universal Testing Machine, recovery work %), and phenolic extraction and total phenolic content (TPC) according to Santarelli et al. (2021). Data collected during the frozen storage were processed by multifactorial ANOVA to evidence the single and combined effects of the freezing method (FM), frozen storage temperature (T) and time (ST) under frozen conditions.

RESULTS & DISCUSSION

Enzymatic assay: BL samples showed a residual POD and PME activity lower than 10 % in accordance with industrial requirements.

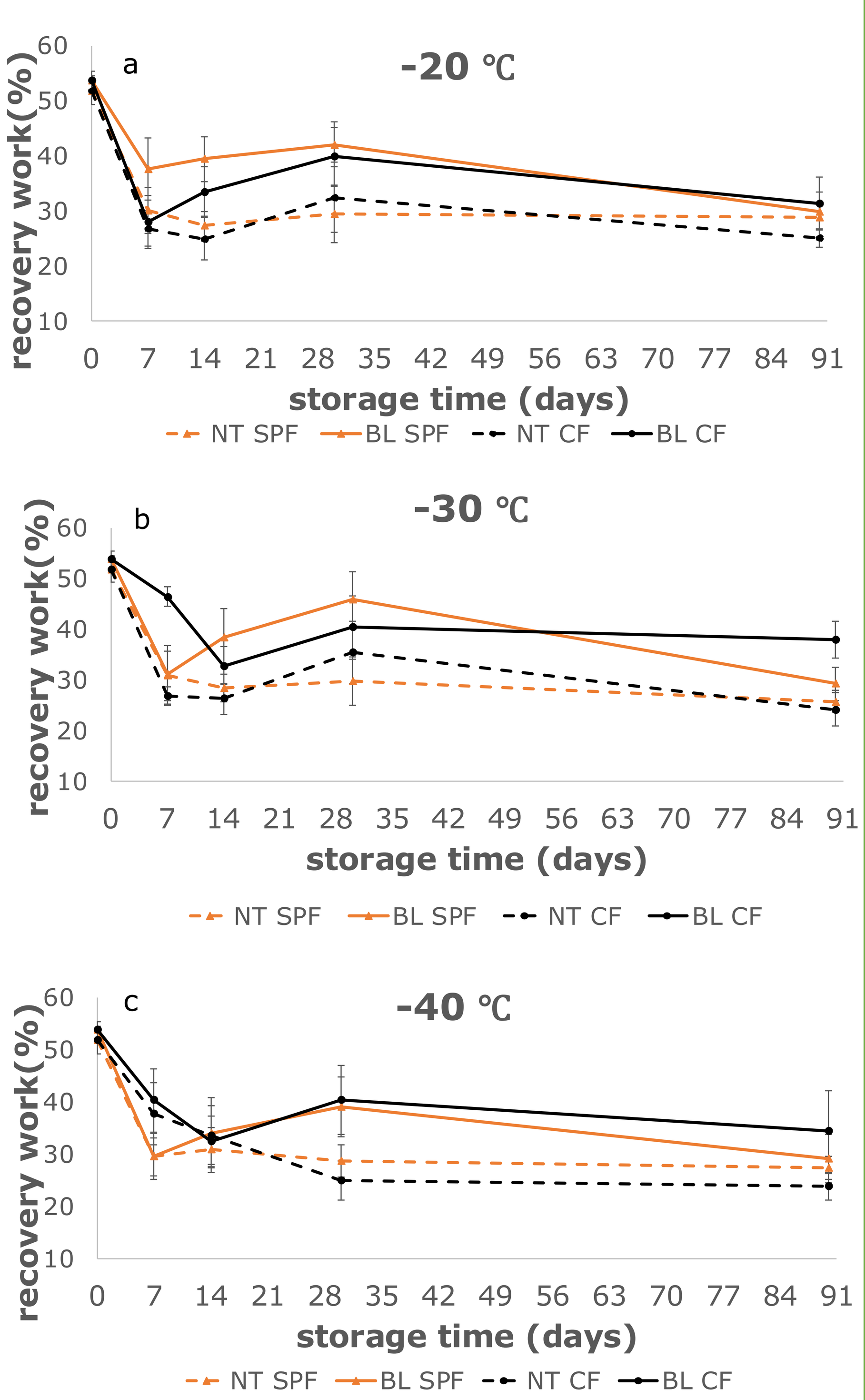

Figure 2. *Recovery work (%) during storage time at different temperatures in SPF and CF*

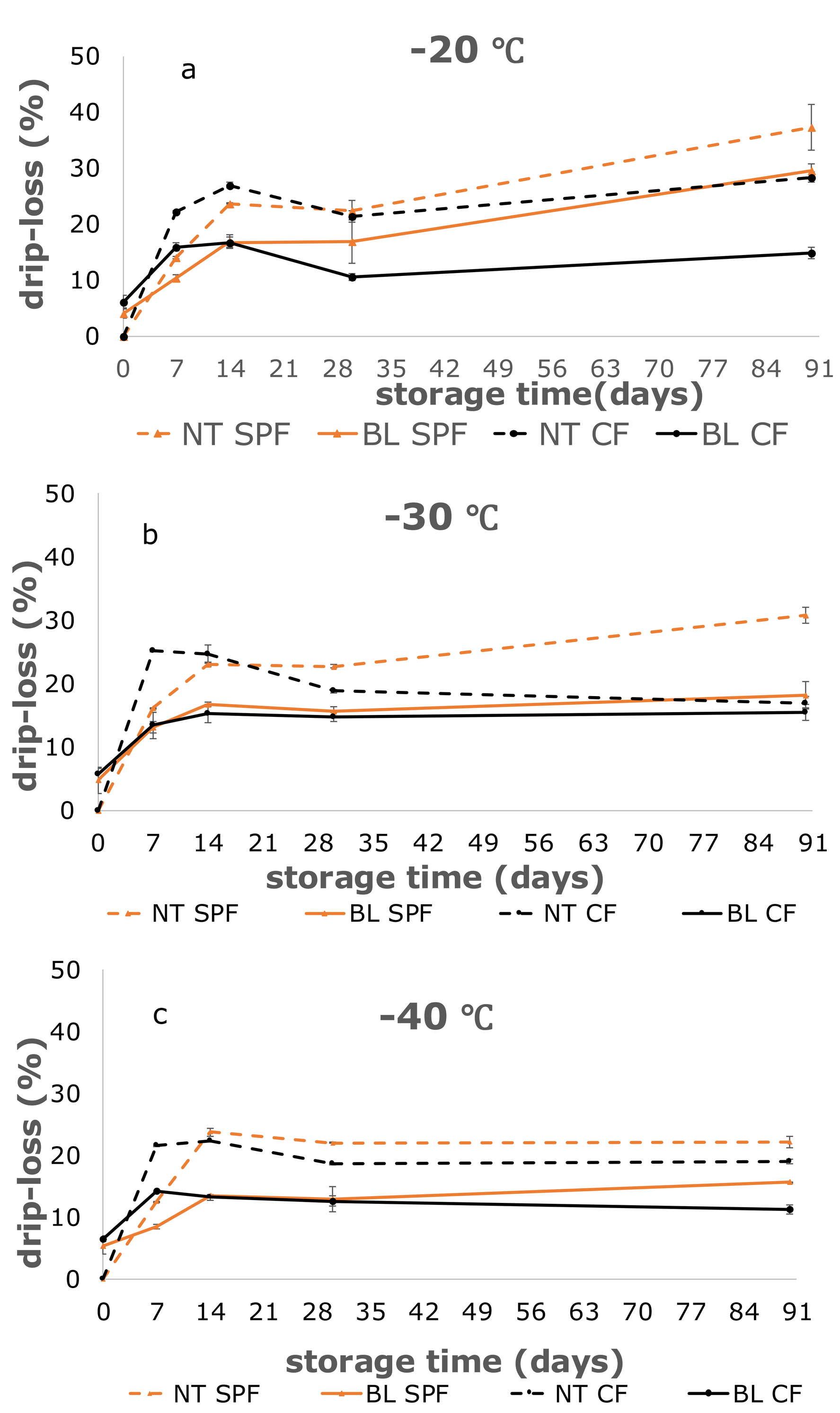

Figure 3. *Drip-loss (%) during storage time at different temperatures in SPF and CF*

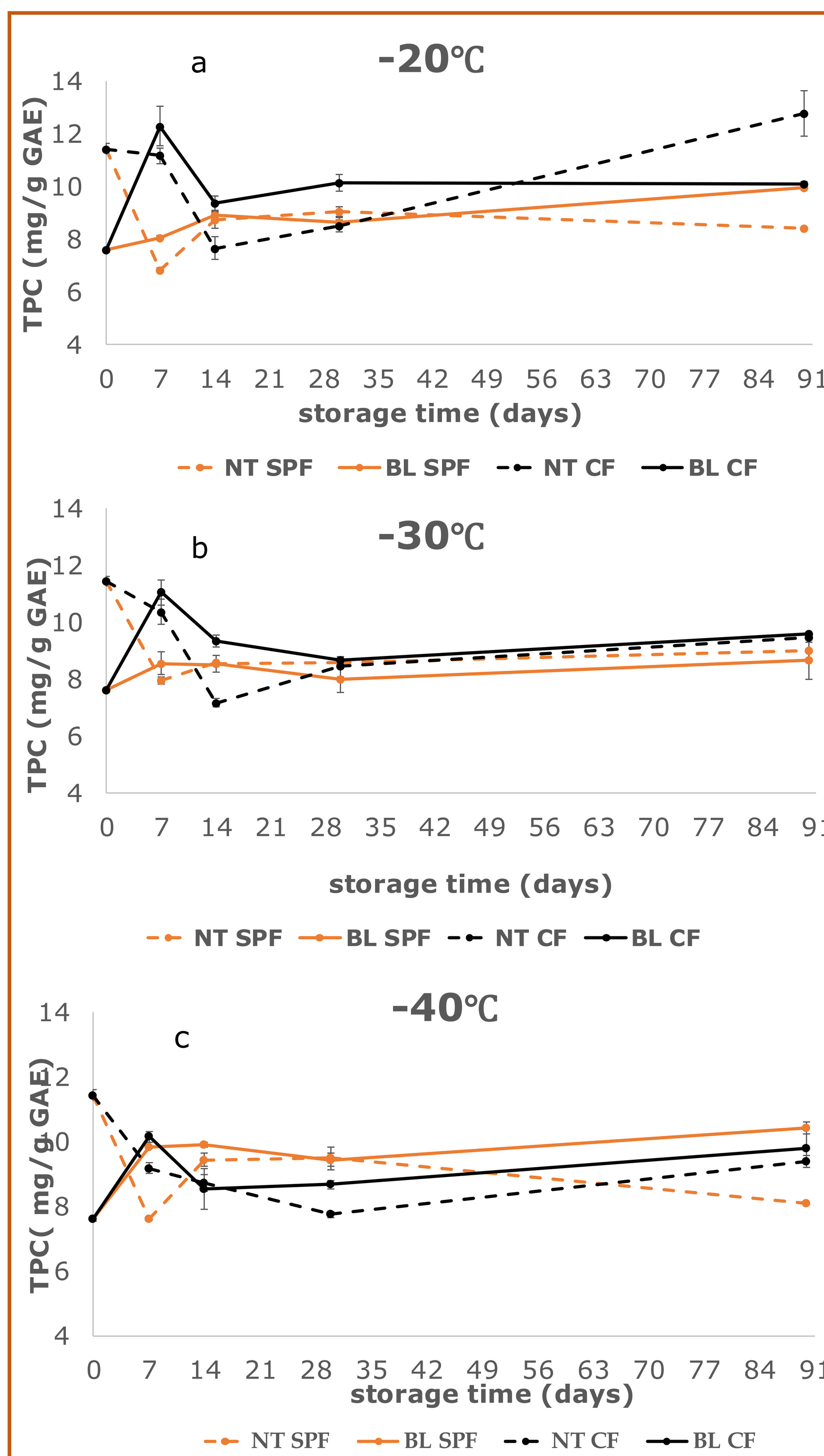

Figure 4. *TPC during storage time different temperatures in SPF and CF*

Figure 1: SPF system highlighted a greater temperature fluctuation and that is due to the use of photovoltaic generators that produce energy not constantly.

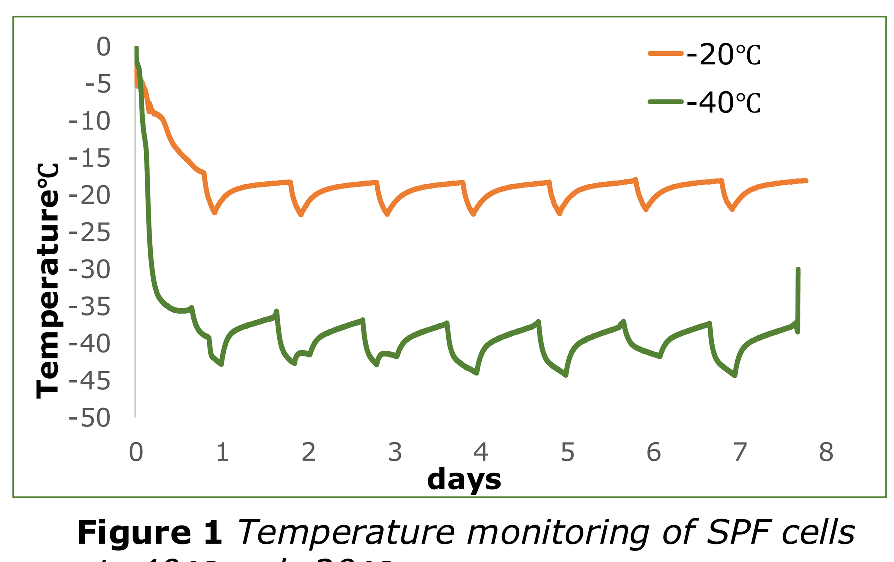

Figure 1 *Temperature monitoring of SPF cells at -40℃ and -20℃*

Figure 4. Blanching reduced carrots' TPC, but storage helped preserve phenol content. Samples stored at -40°C showed the least TPC variation. Among freezing methods, CF better preserved TPC at both -20°C and -30°C.

Table 1. According to multifactorial ANOVA analysis, the combined FM × ST interaction showed a statistically significant effect on all the parameters examined.

Figure 2-3: Over storage, BL samples showed lower drip-loss and higher recovery work after thawing than NT samples due to the inactivation of PME assured by the blanching pre-treatment.

Overall, the highest drip loss was observed in samples stored at -20 °C (p<0.05) and in SPF systems. Recovery work was not affected (p>0.05) by either freezing and storage temperatures or systems.

Table 1. Multifactorial ANOVA (MANOVA) analysis of the individual and interactive effects of Freezing Method (FM), temperature (T), and frozen storage time (ST) on moisture, drip-loss, TPC, mechanical properties and color parameters

				Mechanical Properties	color				
Factors	moisture (%)	drip-loss	TPC	Recovery work (%)	L*	a*	b*	c*	hº
FM	18***	4.516*	31.76***	ns	13.42***	11.13***	ns	ns	19.6***
T	7**	6.820**	3.44*	ns	ns	ns	ns	5.321**	9.5***
ST	4**	9.265***	10.99***	23.10***	14.68***	4.65**	6.50***	6.709***	ns
FMxT	ns	ns	15.74***	8.50***	ns	ns	ns	5.021**	ns
FMxST	11***	20.992***	42.94***	4.73**	30.35***	22.19***	22.21***	6.157***	4**
TxST	ns	ns	2.24*	2.94**	3.52**	4.52***	7.19***	10.804***	2.2*
FMxTxST	6***	ns	2.92*	5.89***	2.70*	ns	ns	4.388***	ns

n.s. not significant. Significance level *p < 0.05; **p < 0.01; ***p < 0.001.

references

-Neri, L., Hernando, I. H., Pérez-Munuera, I., Sacchetti, G., & Pittia, P. (2011). Effect of blanching in water and sugar solutions on texture and microstructure of sliced carrots. *Journal of food science*, *76*(1), E23-E30.

-Santarelli, V., Neri, L., Moscetti, R., Di Mattia, C. D., Sacchetti, G., Massantini, R., & Pittia, P. (2021). Combined use of blanching and vacuum impregnation with trehalose and green tea extract as pre-treatment to improve the quality and stability of frozen carrots. *Food and Bioprocess Technology*, *14*, 1326-1340.