Pulsed electric field technology as pretreatment to enhance strawberries (*Fragaria ananassa*) drying efficiency and physicochemical quality

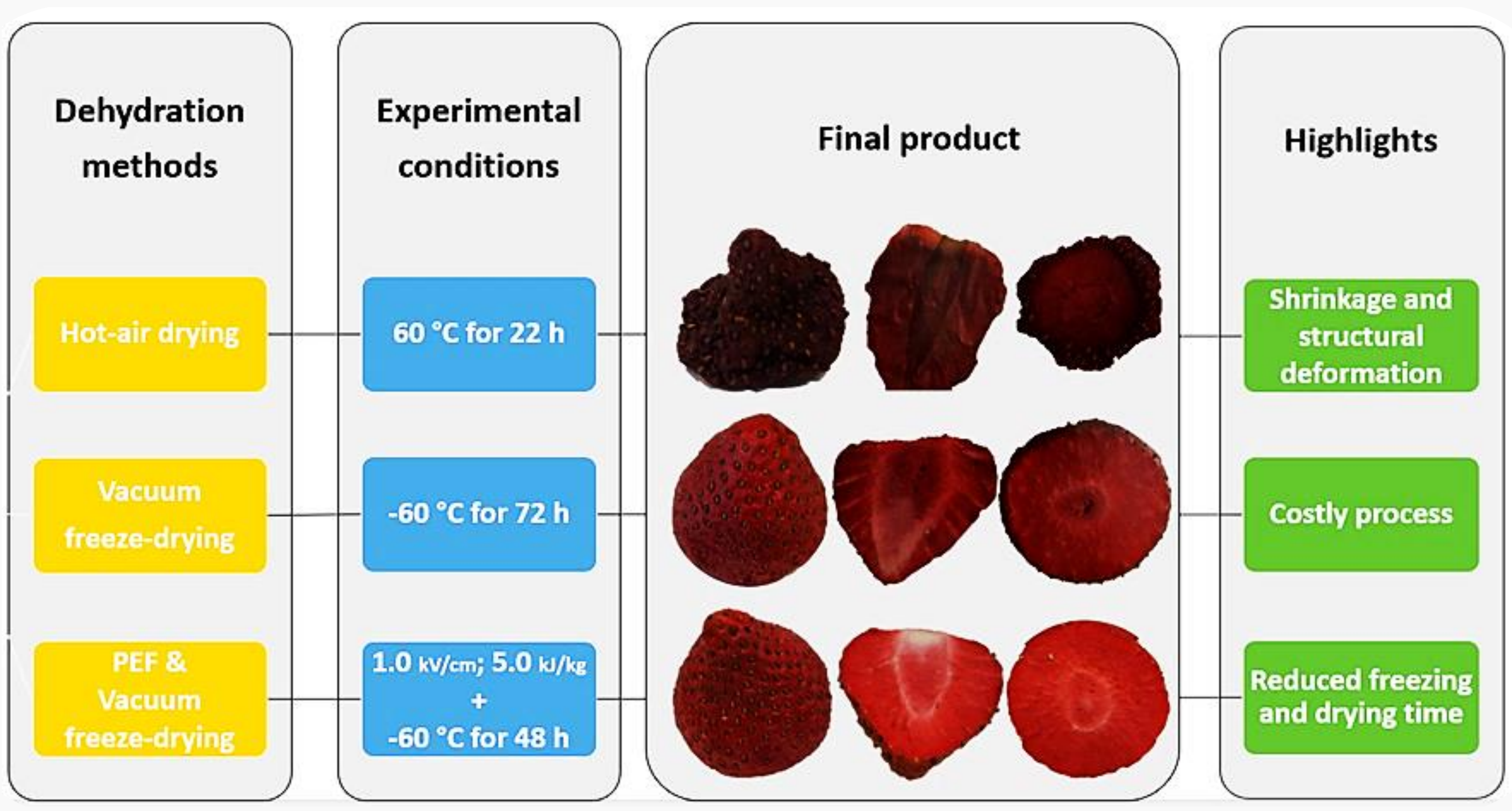
Enrique Pino Hernández[1], Patrícia Antunes[1], Marco Alves[1], Marta B. Evangelista[1,2]

enrique.hernandez@tagusvalley.pt patricia.antunes@tagusvalley.pt marco_alves@tagusvalley.pt marta.evangelista@tagusvalley.pt

[1]INOV.LINEA - Agri-food Technology Transfer and Valorization Center, TAGUSVALLEY – Science and Technology Park, 2200-062, Abrantes, Portugal

[2]LEAF—Linking Landscape, Environment, Agriculture and Food Research Center, Associated Laboratory TERRA, Instituto Superior de Agronomia, Universidade de Lisboa, Tapada da Ajuda, 1349-017 Lisboa, Portugal

Abstract graphic



Introduction

Strawberries (*Fragaria ananassa*) are highly appreciated as a seasonal fruit in innumerous countries around the world. Official data reported that strawberry 2020 worldwide production was around 8.86 million tons [1]. However, strawberries are one of the most delicate and perishable fruits with a very high respiration rate, weight loss and susceptibility to fungal attack [2]. Currently, the best drying method applied to strawberries is freeze-drying. Nonetheless, freeze-vacuum drying is an extremely energy-consuming operation. In order to overcome this problem, the effect of pulsed electric field (PEF) technology at low electric fields has been evaluated in different foods such as tomato, apple and strawberry to overcome this issue. When PEF is applied the biological membrane is electrically damaged and its permeability may be affected temporarily or permanently, which can improve drying and freezing processes [3].

This study evaluates PEF technology as pretreatment to enhance the drying effectiveness of strawberry and improve fruit properties.

Materials and Methods

Raw material Fresh strawberries (var. Savana) were obtained at an industrial unit (Horta Grande Agrifood Company) of Abrançalha de Cima, Abrantes. Strawberry fruits (≈10 kg) were produced in semi-hydroponics conditions and manually harvested.

Treatments i. dried by conventional hot-air drying, ii. fruits pretreated with PEF (treatment was applied using a bipolar pulse protocol) and dried by freeze-drying (at a pressure of 0.06 mbar), and iii. freeze-drying alone. Before freeze-drying, samples were frozen using a rapid air-blast freezer (−35°C). The temperature inside the sample geometrical center was measured with a thermocouple. Finally, dried strawberries were packaged in anti-humidity metallized bags and stored at room temperature for subsequent analysis.

Characteristics analyzed Ascorbic acid, color, pH, aw, titratable acidity, and texture were measured. The freezing and drying time were also evaluated. Furthermore, consumer-based sensory evaluation was conducted using (i) acceptability and (ii) preference tests (n=30). All parameters were analyzed in dried strawberries transverse slices (thickness 5 mm).

Statistical analysis The results were compared by analysis of variance (ANOVA). The Tukey's test at a significance level of 5 % was used as a post-hoc test using the GraphPad Prism v6. Ink software.

Results and Discussions

PEF pretreatment has the potential to reduce freezing time in 5%. Furthermore, PEF combined with freeze-drying reduces drying time in 34% when compared with freeze-drying treatment alone as a control. As a consequence, total energy consumption, which is a critical industrial and economic aspect, is also reduced.

Table 1. The physicochemical characteristics of strawberries dried by different methods.

Charateritiscs		Hot-air drying	Freeze-drying	PEF & Freeze-drying
	L	47.7 ± 4.7 a	49.0 ± 4.8 a	55.1 ± 3.0 b
Colour	a*	35.6 ± 2.6 a	44.1 ± 2.6 b	43.0 ± 2.7 c
	b*	20.9 ± 2.9 a	25.3 ± 3.2 b	22.2 ± 2.6 c
aW		0.3 ± 0.0 a	0.2 ± 0.0 b	0.3 ± 0.01 c
Texture – Force (N)		11.5 ± 6.4 a	16.6 ± 6.9 b	21.1 ± 9.8 c
Ascorbic acid (mg/100g)		6.5 ± 0.01 a	44.6 ± 0.01 b	37.0 ± 0.02 c
pH		3.6 ± 0.01 a	3.5 ± 0.01 a,b	3.4 ± 0.1 b
Titratable acidity (mg/100g)		27.0 ± 0.2 a	30.1 ± 0.4 b	30.4 ± 0.3 b

Values followed by different superscript letters on the same line indicate a significant difference between the samples ($p < 0.05$).

When compared to control samples (Table 1), PEF pretreated and freeze-dried samples presented a higher ascorbic acid content, ≈7 and 6 times more, respectively. Color and acidity analysis showed similar results in PEF and freeze-drying alone samples.

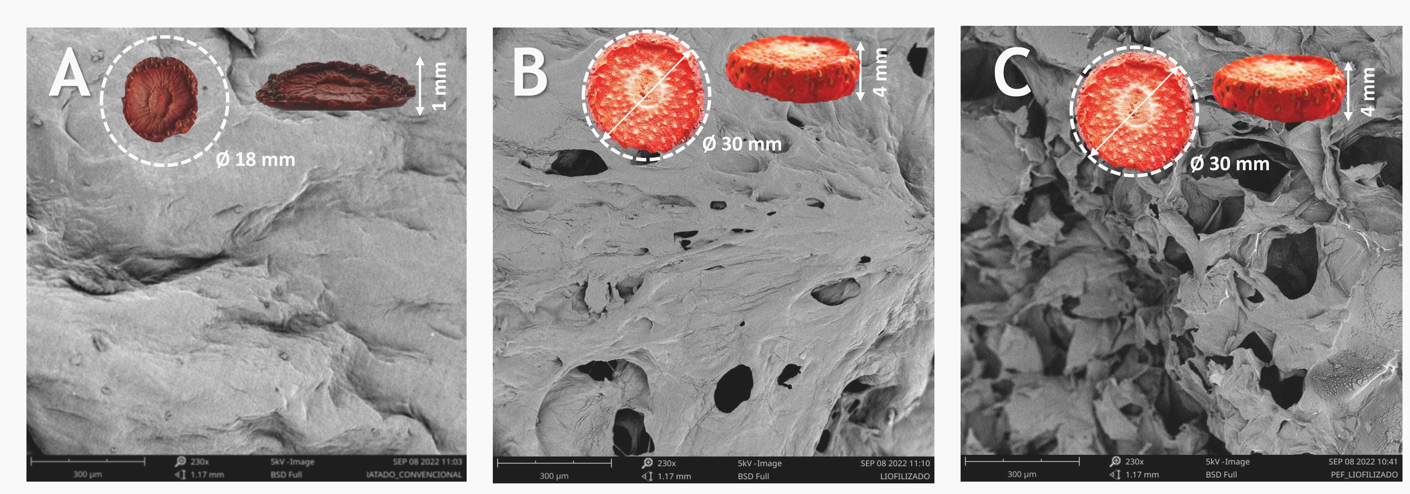


Figure 1. Microstructure images of strawberries dried by different methods. A- Hot-air drying, B- Freeze-drying, C- PEF & Freeze-drying.

PEF-pretreated samples were characterized by high structural quality. Also, in PEF pretreated fruit tissues, the heat and mass transfer processes are enhanced when compared to non-treated tissue, due to electroporation (Figure 1).

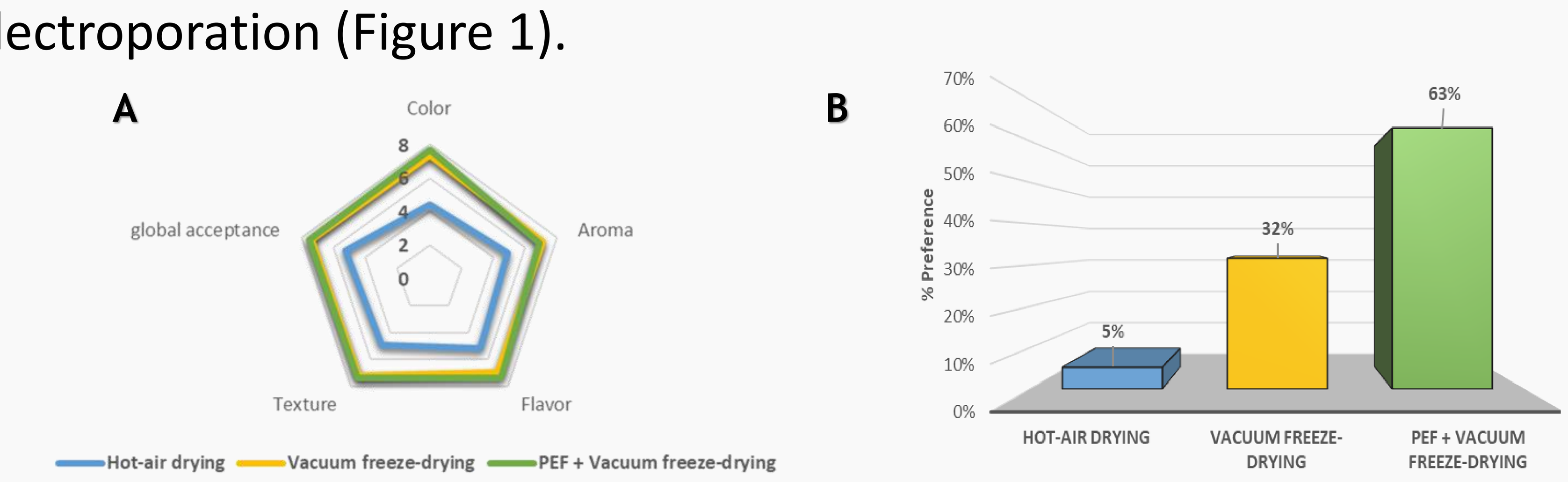


Figure 2. Results of consumer-based sensory evaluation. A- acceptability and B- preference tests.

Freeze dried strawberries with and without PEF pretreatment (Figure 2) had similar consumer acceptance. However, fruit pretreated by PEF had the highest preference.

Conclusions

The application of PEF pretreatment before freeze-drying allows greater productivity and sustainability at the industrial level drying process and ensures greater preference for the product by the consumer. Based on the promising results obtained, the scale-up of this application to an industrial scale should be addressed.

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Shared co-first authorship The second author contributed equally as the first author.