Topic: *Innovative and sustainable food ingredients and products*

Food processing by pulsed electric fields: Challenges and sustainable opportunities for industries

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Abstract

Sustainability in the food industry requires innovation in both its processes and product ingredients as a strategy to provide consumers with not only high-quality food, but, above all, healthier and safer products, while achieving a better economic, environmental and social performance [1]. PEF is based on the application of short-duration pulsed power to food products, typically with a field strength ranging from 1 to 30 kV/cm. This technology promotes cell electroporation, a phenomenon that induces greater formation of pores in the biomass cell membrane [2,3]. This study aimed to analyze three case studies developed at TAGUSVALLEY in Portugal, identifying two innovative approaches towards sustainable development in terms of product quality and process efficiency, namely, industrial forward-looking processes assisted by PEF.

Methodology

• ***The first case studies***, represents a business model redesign oriented to sustainability, consisting in the reconfiguration of the conventional olive oil extraction with PEF-assistance pre-treatment (Figure 1), which could have a positive impact on production efficiency, maintaining the extra-virgin classification[4].

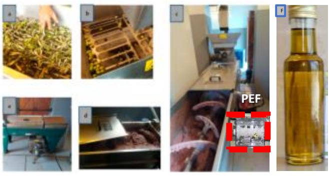

Figure 1. Olive oil extraction line with the PEF chamber. (a) Cleaning; (b) crushing; (c) PEF treatment; (d) malaxation; (e) centrifugation; (f) final product.

• ***The second case studies***, focused on microbial inactivation by PEF for shelf-life extension and to ensure the safety and quality of Reineta Parda apple puree (Figure 2) compared to conventional thermal pasteurization[3].

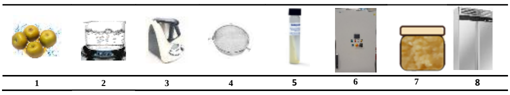

Figure 2. Sample preparation for PEF processing at laboratory scale. (1) Washing and cutting, (2) Pre-treatment, (3) Mash, (4) Refining, (5) Escherichia coli inoculation, (6) PEF pasteurization, (7) final product, (8) Refrigerated storage.

• ***The third case studies,*** also implies the utilization of PEF as a pre-treatment (Figure 3) but, in this case, the strategy used was to improve freeze-drying efficiency on strawberries[5].

Figure 3. Sample preparation for freeze-drying processing.

Results

The results showed that the incorporation of PEF (2 kV/cm, and 8.5 kJ/kg) in olive oil production reduced the malaxation step by 33% without compromising the yield or extra-virgin classification. This efficiency leads to a potential 12.3% increase in annual olive oil production, with a 12.3% and 36.8% rise in revenue and gross profit, respectively (Table 1).

Table 1. Economic viability results of control and PEF olive oils.

	Control	PEF
Olive production per cycle (kg)	350	350
Cycle time (min)	160	145
Revenue (EUR)	215,819	242,252
Gross profit (EUR)	18,368	25,123
Olive oil production (L)	33,617	37,734
Energy consumption (kW)	48,791	49,948

• Considering apple puree processing, PEF at 10 kV/cm and 57.2 °C, reduced E. coli counts by 5.8 log CFU/g, thus achieving the pasteurization status (at least 5 log CFU/g inactivation) (Figure 4). The investment required on PEF equipment for upgrading pasteurization process under study showed an internal rate of return of 21.54% and a payback of 4 years. The breakeven point for the 1st year of project is reached when 163.500 kg of product are sold or when revenue is 1,03 M€, which means that these are the quantities needed to cover all costs (fixed and variable)[6].

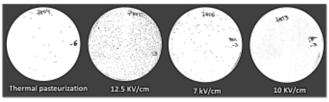

Figure 4. *E. coli* inactivation by thermal and non-thermal pasteurization processes.

• On the other hand, the SEM images revealed a porous structure on freeze dried fruits, with the highest porosity observed in the samples pre-treated with PEF at 1 kV/cm, bipolar pulse of 15 µs, and 60 Hz. PEF significantly improved the freeze-drying efficiency since samples pre-treated with PEF had lower moisture (9.73%) when compared with samples without pre-treatment (10.48%). However, PEF pre-treatment did not impact the duration of freeze-drying process (Figure 5).

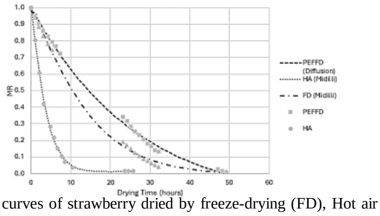

Figure 5. Drying curves of strawberry dried by freeze-drying (FD), Hot air (HA) and freeze-drying with PEF (PEFFD) with the best fitting model analysed.

Conclusion

This study can guide, support and provide solutions for small, medium, and large companies, in the innovation and adoption of more efficient and sustainable processes. PEF can help to surpass the challenges associated with thermal food processing methods, for instance, high temperatures and processing time, operational costs and alteration of food nutrient components.

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(PEF can contribute to a food system that aims for industrial innovation and sustainability)