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Sensory evaluation test of electroporated carrots

Pavel Kouřím[1], Lenka Kouřimská[2], Izabela Kovaříková[2], Jiří Blahovec[1]*

[1]Department of Physics, Faculty of Engineering, Czech University of Life Science Prague, Prague, Czech Republic
[2]Department of Microbiology, Nutrition and Dietetics, Faculty of Agrobiology, Food and Natural Resources, Czech University of Life Science Prague, Prague, Czech Republic

**Corresponding author: kourim@tf.czu.cz*

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Abstract: Two types of samples were prepared from fresh carrot roots. The first type represented samples of untreated carrots. The second type was treated with a pulsed electric field. Nine specific sensory properties characterising the carrot root tissue were evaluated by means of a sensory profile method to determine the differences between the untreated and treated carrot samples. For the resilience and elasticity, which were evaluated by the fingers, and the juiciness, which was evaluated in the mouth, significant differences were found between the two types of samples.

Keywords: electroporation; non-thermal method of preparation; PEF; tasting; vegetable

The last twenty plus years have been associated with the rapid development of technologies using the application of pulsed electric fields (PEFs) in their direct action on natural food products (Vorobiev and Lebovka 2020). The new processing methods have made it possible to rationalise the processing of many plant products, to improve the separation of some components, including that of moisture, and, last but not least, to improve the storage, quality and distribution of new products. The possibility of using pulsed electric fields directly in the kitchen for the preparation of meals from natural products intended for fast consumption has been shown in research (Blahovec et al. 2017). The effect of this process not only changes the objective parameters of the product, such as digestibility, better use of biologically active substances, etc., but also its sensory properties. The aim of this study was to see the effect of PEF treatments on the sensory properties of carrots.

MATERIAL AND METHODS

Carrots from the university experimental station (variety Jereda) were used for testing. The largest roots from the harvest, four months after sowing, were selected. The diameters of the roots in the widest part were about 35 mm ± 5 mm. The top layer was removed with a scraper before treatment. Slices with a thickness of 1.5 mm ± 0.1 mm were precisely cut with a slicer. The middle parts of the slices with the xylem core were cut out using a circular tool (with a diameter of 15 or 20 mm corresponding to the xylem area). The untreated sample, extracted xylem core and PEF treated sample are shown in Figure 1.

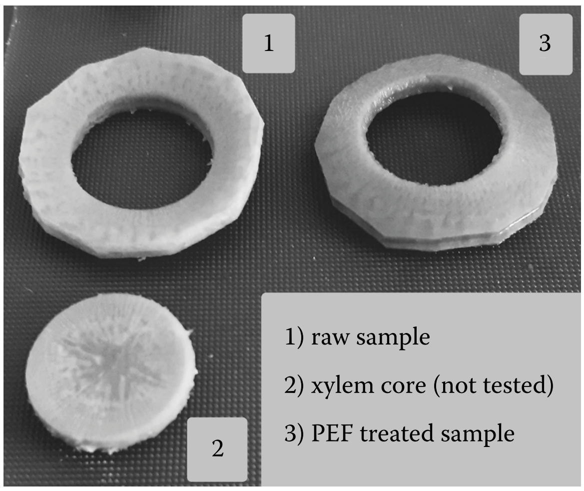

Figure 1. Typical specimens used in the experiments
For more information on the dimensions, see the text

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Application of PEF pulses to the slices was performed in a PEC-1 device (Czech University of Life Sciences Prague 2019) working with 11 ms long pulses of an alternated modified sin wave with a frequency of 18 kHz and an amplitude 140–155 V. The required intensity of the electric field was achieved by choosing the thickness of the tested specimens, which were placed between the electrodes. Using two slices with a final thickness of 3 mm, we reached a peak pulse value of about 490 $V \cdot cm^{-1}$ as the main pulse parameter used in our experiments. By repeating the individual pulses, it is possible to achieve the required degree of the cell membrane disruption (electroporation) due to the PEF treatment of the specimen. To increase the effect of the electric field in our experiments, the pulse was repeated ten times with a delay of 0.2 s between the pulses. The application of the pulsed electric field changes the electric properties of the tested specimens. The reduction of the impedance magnitude and the phase angle decrease (indicating loss of the capacitive character of the tissue impedance) after application of 10 pulse series at different intensity levels is demonstrated in Figure 2. This figure shows that our research at an intensity of 490 $V \cdot cm^{-1}$ leads to a reduction in the specimen impedance magnitude to approximately one tenth of the initial value which proves almost the maximum level of PEF induced cellular tissue disintegration (De Vito et al. 2008).

The sensory evaluation of the samples was performed according to the General guidance for establishing a sensory profile (ISO 13299:2016) and the General guidance for the design of test rooms (ISO 8589:2007). The trained sensory assessors comprised six university students and employees at an age range from 23 to 59 years old. One pair of samples consisting of the raw and PEF treated carrot root samples was served to each panellist. The samples were labelled with randomised four-digit codes. Linear unstructured graphical 100 mm scales oriented by description at both ends were used for the sensory profile evaluation of nine descriptors: pleasantness of the odour (0% = very bad, 100% = excellent), pleasantness of texture (0% = very bad, 100% = excellent), resilience (0% = very breakable, 100% = very flexible), hardness (0% = very soft, 100% = very hard), elasticity (0% = very short, 100% = very elastic), fragility (0% = very fragile, 100% = very tough), cohesion (0% = very crumbly, 100% = very cohesive), juiciness (0% = very dry, 100% = very juicy) and intensity of the woody taste (0% = imperceptible, 100% = very strong). The pleasantness of the texture, resilience, hardness, and elasticity were evaluated by the fingers, while the other descriptors were evaluated in the mouth. The samples were evaluated immediately after their treatment. Drinking water was used as a taste neutraliser. For statistical processing, an *F*-test was used to test the null hypothesis that the variances of the descriptor values of the raw and PEF treated samples are equal and an appropriate two-sample *t*-test method was selected to test the null hypothesis that the means of the descriptor values of the raw and PEF treated sample are equal. Both types of tests were performed for a significance level of $\alpha = 0.05$.

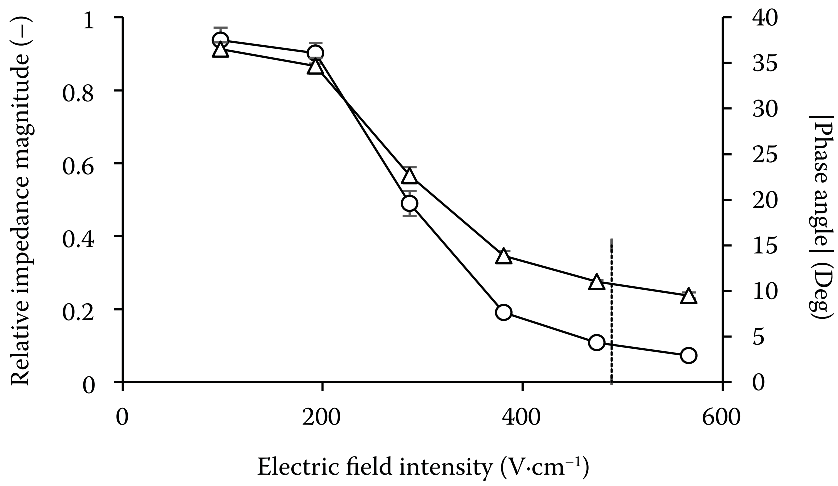

Figure 2. Relative impedance magnitude (o) and absolute value of the phase angle (Δ) plotted against the maximum value of the applied pulsed electric field (PEF)

The bars denote the standard errors ($n = 3$). Electric field intensity level applied to evaluated samples is indicated by a dotted line

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RESULTS AND DISCUSSION

The results of the sensory evaluation of nine descriptors of both the raw and PEF treated carrot samples are presented in the web graph in Figure 3 and are shown in more detail in Table 1.

The relative change of the sensory descriptors due to the PEF application, denoted as D_r can be expressed as Equation (1). The obtained D_r values are given in Figure 4.

$$D_r = \frac{D_{PEF} - D_{raw}}{D_{raw}} \quad (1)$$

where: D_{raw} – the mean values of sensory descriptor in the raw state; D_{PEF} – the mean values of sensory descriptor in the pulsed states.

The statistical comparison of the raw and PEF treated samples showed significant differences in the resilience (P-value << 0.001), elasticity (P-value << 0.001) and juiciness in the mouth (P-value = 0.042) at a significance level of α = 0.05. For the pleasantness of the odour (P-value = 0.225), pleasantness of the texture (P-value = 0.512), hardness (P-value = 0.070), fragility in the mouth (P-value = 0.308), cohesion in the mouth (P-value = 0.781) and intensity of the woody taste (P-value = 0.117), no significant differences were found between the samples at a significance level of α = 0.05.

Table 1. Mean values and standard errors (the number of repetitions n = 6) of the sensory descriptors of the raw (D_{raw}) and PEF treated (D_{PEF}) samples

Sensory descriptor	D_{raw} (%)		D_{PEF} (%)	
	mean	standard error	mean	standard error
pleasantness of odour	59.2	2.5	67.7	5.9
pleasantness of texture	57.7	6.8	63.0	4.0
resilience	45.8	3.8	73.7	3.9
hardness	61.8	3.0	46.0	6.8
elasticity	45.7	4.0	76.3	4.0
fragility in mouth	43.8	5.5	52.8	6.3
cohesion in mouth	54.8	4.3	56.8	5.5
juiciness in mouth	48.0	4.8	62.7	4.1
intensity of woody taste	34.3	8.3	18.5	4.0

Greater changes in some mechanical properties caused by a loss of the turgor pressure of the tissues affected by the electroporation were previously repeatedly directly measured (Blahovec et al. 2015). The assessors perceived the changes in the resilience and elasticity of the sample as the most significant of all. Immediately after the application of the PEF, the secretion of juice on the surface of the samples was observed. It should indicate the disruption of the cell membranes allowing the release of juice (Blahovec et al. 2021) and the assessors' evaluation confirmed the greater juiciness of the PEF treated samples. Based on the preparatory experiments, the pleasantness of the odour and intensity of the woody taste were added as the evaluated descriptors. However, it turned out that the degree of the change in the pleasantness of the odour varied according to the carrot variety and this change was rated by the assessors as being small during testing. The decrease in the intensity of the woody taste was perceived more strongly.

In further experiments, more carrot varieties should be tested, it would be good to perform the tasting after a longer time as the treatment would then better correspond to the time between the preparation and consumption of the food in everyday life and, as carrot roots are normally consumed whole, samples should be tested without removing the xylem core.

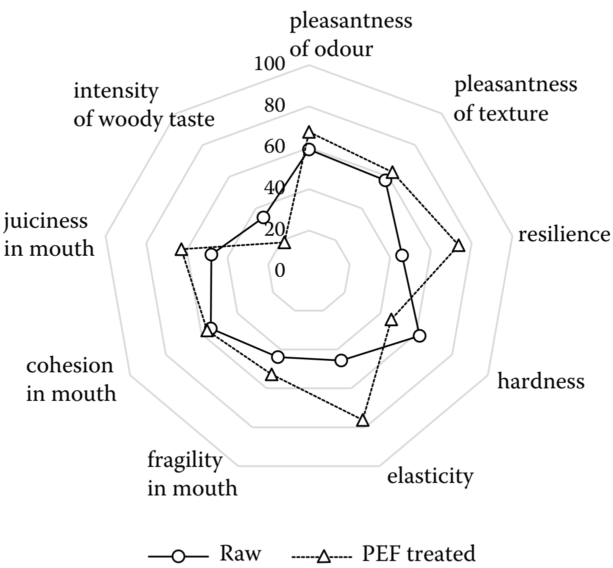

Figure 3. Sensory descriptors of the raw and PEF treated samples (mean values)

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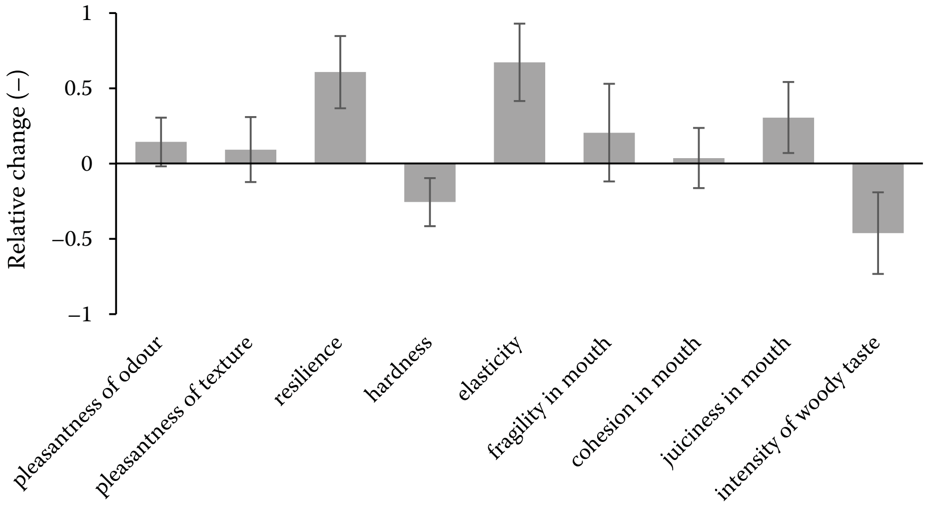

Figure 4. Relative changes in the sensory parameters defined by Equation (1)

The bars denote the standard errors (n = 6)

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