Photopyroelectric Technique Applied to Thermal Characterization of Butter, Clarified Butter and Vegetable Oils, at Frying Temperatures

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The use of oils, fats and their blends, as a frying medium, plays a significant role in various food applications; however, during the frying process, oils and fats undergo multiple changes that modify their chemical composition and physical properties, which can accelerate the oxidation process and produce several toxic compounds [1,2]. For a good frying oil, it is important to consider the high oxidative stability, low levels of saturated/trans fats, and an adequate ratio between saturated and unsaturated fatty acids. Blending vegetable oils and fats with different fatty acid profiles can enhance smoke points, thermal and oxidative stability and nutritional quality [3,4].

The present study is based on the photopyroelectric (PPE) technique in front configuration, using the reference sample method [5,6], to determine the thermal properties of liquids. Also, Fourier transform infrared spectroscopy was used to evaluate the degradation effect of the samples during frying. Fats and vegetable oils, including butter (BT), clarified butter (CBT), extra virgin olive (EVOO), extra virgin avocado (EVAO), safflower (SFO), and soybean (SBO) oils were heated at 120 °C and 180 °C. Thermal diffusivity of samples (α_s) was obtained by the ratio of tangents of PPE phase signals as $\alpha_s = \alpha_r$ (tan ϕ_s/tan ϕ_r) as a function of frequency (f); where α_r is the thermal diffusivity of the reference; ϕ_s and ϕ_r are the PPE phase signal data for the sample and the reference, respectively. Water was used as reference for all samples. The thermal conductivity of samples (k_s) was obtained using the equation $k_s=k_r$ ($\alpha_s V_r/\alpha_r V_s$), where k_r is the thermal conductivity of the reference, V_r and V_s are the PPE signal amplitude for the reference and samples, respectively. The mean values between the 14 Hz and 40 Hz range were used to determine α_s and k_s (Fig 1a). This range guarantees a thermally thin pyroelectric sensor and a thermally thick sample. Figs. 1b and 1c show the thermal diffusivity and conductivity of studied fats and vegetable oils at different temperatures, respectively. Based on both thermal properties, the thermal effusivity (e_s) and the volumetric heat capacity (ρc) values were also determined.

References

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