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Effect of Initial Product Temperature on Core Temperature Development and Inter-Stage Carry-Over Heating in Two-Stage Deep-Fat Frying of Chicken Thigh

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Abstract

Two-stage deep-fat frying is widely used in industrial poultry processing, yet the thermal response at the geometric center of chicken thigh throughout this multi-stage sequence remains poorly characterized in quantitative terms. This study investigated the effects of initial product temperature (T_0) and piece weight on core temperature development by monitoring core temperature continuously in 60 boneless skin-on chicken thigh pieces (36-54 g, T_0 = 3.3-32.6°C) across a complete two-stage frying protocol consisting of Stage 1 at 180°C for 50 s, an inter-stage rest of 135 s in ambient air, Stage 2 at 170°C for 200 s, and post-frying monitoring to 555 s. Initial product temperature was the dominant predictor of heating rate: Pearson correlation between T_0 and slope was $r = -0.831$ ($p < 0.001$), with T_0 accounting for 69.0% of variance, while piece weight accounted for only 7.4% in isolation and contributed 0.3% in multiple regression beyond T_0. Core temperature continued to rise during the inter-stage rest period by a mean of 19.4 ± 3.3°C without oil contact, accounting for 25-26% of total core temperature gain over the full sequence. This carry-over heating was inversely related to T_0 ($r = -0.625$, $p < 0.001$), consistent with Fourier's law of transient conduction: colder pieces develop steeper surface-to-center thermal gradients at Stage 1 exit, driving greater inward heat flux during rest. One-way ANOVA across three T_0 tertile groups confirmed highly significant differences in both heating rate ($p < 0.001$) and carry-over heating ($p < 0.001$), with Cohen's d ranging from 1.60 to 2.55 across pairwise slope comparisons. All pieces reached the USDA-FSIS minimum internal temperature of 74°C, with time-to-74°C spanning 300 s to 510 s, a 210-second spread that piece weight alone cannot predict. These results indicate that T_0 must be incorporated as a required input in predictive heat transfer models for two-stage fried poultry systems, and that the inter-stage rest period must be explicitly represented to avoid systematic underestimation of core temperature at Stage 2 entry.

References

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