Original scientific paper
UDC 664.661/.663:664.665-026.65

NON-CONTACT TEMPERATURE MEASUREMENT BASED ON INFRARED RADIATION FOR BREAD BAKING PROCESS

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Abstract

The control of baking temperature is prime important for bread making since it directly affects the quality attributes of bread products and the efficiency of energy utilization. This study proposes a technique to measure the product's surface temperature based on infrared radiation (IR) for the bread-baking process.

Wheat dough samples were baked with different three-step temperature settings (180 ^{0}C - 120 ^{0}C - 170 ^{0}C C, 180 ^{0}C - 120 ^{0}C - 180 ^{0}C, and 180 ^{0}C - 120 ^{0}C - 190 ^{0}C). A thermal image camera and an infrared sensor were used to determine the values of emissivity (ε). The total weight loss was calculated by the weight difference between the dough and bread product. Data were analyzed using the analysis of variance (ANOVA) and the Turkey test at 0.05 level of significance.

It was found that the weight loss of bread products obtained from different baking temperature settings differed significantly ($p < 0.05$). The total weight loss of samples was in the range of 10.5% - 12.6%. During the first stage, where the core temperature (TCore) and the surface temperature (TSurf) increased to 40 ^{0}C, and 98 ^{0}C, respectively, a slight volume expansion was observed while weight loss was not detectable. In the second stage, TCore and TSurf respectively increased to 60 ^{0}C, and 113 ^{0}C. The volume expansion was obvious, and the weight loss could be observed. Finally, when TCore and TSurf increased to 98 ^{0}C, and 140 ^{0}C, respectively, in the last stage, most of the weight loss was found, primarily due to moisture evaporation and the crust turned brown with slightly darker shades upon increasing the baking temperature from 170 ^{0}C to 190 ^{0}C. The emissivity (ε) values inferred from the measurements tended to decrease from 0.95 to 0.87. By considering ε as a constant value for a 10 ^{0}C -interval within this baking stage, a good agreement between the product's surface temperature measured with the IR sensor and that measured with a thermocouple was found, with a correlation coefficient (r) of 0.99.

This finding suggests the potential of the infrared radiation technique for real-time, non-contact temperature measurement to monitor and control the bread-baking process.

***Key words**: Bread, Baking, Emissivity, IR sensor.*