Classification of Kimchi using Laser-Induced Breakdown Spectroscopy and *k*-Nearest Neighbors Modeling

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Kimchi is a traditional Korean food with rich health benefits and also a symbol of Korean food culture [1]. As kimchi continues to gain popularity worldwide, its production is being spread beyond South Korea. Nowadays, most of the kimchi consumed in South Korea are produced in South Korea and also imported from China. This work reports a simple and reliable methodology classifying cabbage kimchi products consumed in South Korea according to the producing countries. It is based on the combination of laser-induced breakdown spectroscopy (LIBS) and *k*-nearest neighbors (*k*-NN) modeling algorithm. LIBS is one of the elemental analysis techniques using optical emissions from laser-induced plasmas. In typical LIBS analysis, a pulsed laser beam is focused on the sample surface to produce a transient plasma. The laser-induced plasma subsequently cools down by emitting light within a few tens of microseconds. The optical emission from the laser-induced plasma conveys information about the elemental composition of the samples which are used for both quantification of constituent elements and classification of the samples. LIBS spectra of 125 kimchi samples from China (73 samples) and South Korea (52 samples) were recorded and analyzed to model their geographical origin. Emission lines of seven elements, Na, K, Mg, Ca, C, H, and O, were observed in the LIBS spectra. Their discrimination capabilities were evaluated using the metric of interclass distance. The Mg II and K I emissions at 279 nm and 766 nm, respectively, were found to be effective in discriminating each kimchi sample class from the other one. The Chinese and Korean kimchi classes were modeled first using each of the Mg II and K I emission intensities. These 1-dimensional *k*-NN models showed comparable performances in classification accuracy: 84.8 % and 86.4 %, respectively. However, the 2-dimensional *k*-NN model considering both Mg II and K I emissions intensities outperformed the 1-dimentional models showing 92.8 % classification accuracy. The discrimination capabilities of the Mg II and K I emissions were found to be complementary to each other; the Mg II emission intensity is stronger in discriminating Chinese samples and the K I emission intensity is better in discriminating Korean samples. Our results indicate that the combination of the simple elemental analysis techniques, LIBS, and a classical non-parametric modeling approach, *k*-NN, is promising as a practical methodology for origin distinction of kimchi in markets.

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