

# Stacked ensemble learning based on deep transfer learning models for food ingredient classification and food quality determination

## Abstract

Food safety is critical in protecting consumers from foodborne diseases. The public currently classifies and determines food ingredients and their quality based on appearance, aroma, and other characteristics. Existing food inspection machines often focus on single characteristics, resulting in incomplete and inaccurate information. Hence, developing methods that analyse multiple characteristics is necessary for high-accuracy classification. This research proposed an effective stacked ensemble deep transfer learning algorithm using eight popular transfer learning algorithms as a base classifier and combining them with the Adaptive Neuro-Fuzzy Inference System as a meta-classifier to analyse imaging, odour, and capacitive sensing approaches. Twenty-four food samples classified according to freshness, maturity, ripeness, and disease levels were analysed using the proposed stacked ensemble EfficientNet algorithm, achieving the highest accuracy rate of 0.916 and 0.933 in food ingredient classification and quality determination, respectively. This research demonstrated the system's reliability for deployment in classifying food ingredients in dishes.

## Keywords

Adaptive neuro-fuzzy inference system; Food ingredient classification; Food quality determination; Stacked ensemble deep transfer learning