A new 'e-nose' and computer vision help researchers cook the perfect chicken

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Skoltech researchers have found a way to use chemical sensors and computer vision to determine when grilled chicken is cooked just right. These tools can help restaurants monitor and automate cooking processes

in their kitchens, and perhaps one day even end up in your 'smart' oven. The paper detailing this research results, supported by a Russian Science Foundation grant, was published in the journal *Food Chemistry*.

How do you tell that chicken breast on your grill is ready for your plate? You probably look at it closely and smell it to make sure it is done the way you like it. However, if you are a restaurant chef or head cook at a huge industrial kitchen, you cannot really rely on your eyes and nose to ensure uniform results up to the standards your customers expect. That is why the hospitality industry is actively looking for cheap, reliable, and sensitive tools to replace subjective human judgment with automated quality control.

Professor Albert Nasibulin of Skoltech and Aalto University, Skoltech senior research scientist Fedor Fedorov and their colleagues decided to do just that: get an 'e-nose,' an array of sensors detecting certain components of an odor, to 'sniff' the cooking chicken and a computer vision algorithm to 'look' at it. 'E-noses' are simpler and less expensive to operate than, say, a gas chromatograph or a mass spectrometer, and they have even been shown to be able to detect various types of cheeses or pick out rotten apples or bananas. On the other hand, computer vision can recognize visual patterns—for instance, to detect cracked cookies.

The Skoltech Laboratory of Nanomaterials, led by Professor Nasibulin, has been developing new materials for chemical sensors; one of the applications for these sensors is in the HoReCa segment, as they can be used to control the quality of air filtration in restaurant ventilation. A student of the lab and co-author of the paper, Ainul Yaqin, traveled to Novosibirsk for his Industrial Immersion project. He used the lab sensors to test the effectiveness of industrial filters produced by a major Russian company. That project led to experiments with the smell profile of grilled chicken.

"At the same time, to determine the proper doneness state, one cannot rely on 'e-nose' only but have to use computer vision—these tools give you a so-called 'electronic panel' (a panel of electronic 'experts'). Building on the great experience in computer vision techniques of our colleagues from Skoltech CDISE, together, we tested the hypothesis that, when combined, computer vision and electronic nose provide more precise control over the cooking," Nasibulin says.

The team chose to combine these two techniques to monitor the doneness of food accurately and in a contactless manner. They picked chicken meat, which is popular across the world, and grilled quite a lot of chicken breast (bought at a local Moscow supermarket) to 'train' their instruments to evaluate and predict how well it was cooked.

The researchers built their own 'e-nose,' with eight sensors detecting smoke, alcohol, CO, and other compounds and temperature and humidity, and put it into the ventilation system. They also took photos of the grilled chicken and fed the information to an algorithm that specifically looks for data patterns. To define changes in odor consistent with the various stages of a grilling process, scientists used thermogravimetric analysis (to monitor the number of volatile particles for the 'e-nose' to detect), differential mobility analysis to measure the size of aerosol particles, and mass spectrometry.

But perhaps the most important part of the experiment involved 16 Ph.D. students and researchers who taste-tested a lot of grilled chicken breast to rate its tenderness, juiciness, intensity of flavor, appearance, and overall doneness on a 10-point scale. This data was matched to the analytical results to test the latter against humans' perception who usually end up eating the chicken.

The researchers grilled meat just outside the lab and used the Skoltech canteen to set up the testing site. "Due to the COVID-19 pandemic, we

had to wear masks and perform testing in small groups, so it was a rather unusual experience. All participants were given instructions and provided with sensory evaluation protocols to do the job properly. We cooked many samples, coded them, and used them in blind tests. It was an exciting experience for material scientists mainly and relied on data from sophisticated analytical tools. But, chicken tissues are materials too," Fedorov notes.

The team reports that their system was able to identify undercooked, well-cooked, and overcooked chicken quite well, so it can potentially automate quality control in a kitchen setting. The authors note that to use their technique on other parts of the chicken—say, legs or wings—or for a different cooking method, the electronic 'nose' and 'eyes' would have to be retrained on new data.

The researchers now plan to test their sensors in restaurant kitchen environments. One other potential application could be 'sniffing out' rotten meat at the very early stages when changes in its smell profile would still be too subtle for a human nose.

"We believe these systems can be integrated into industrial kitchens and even in usual kitchens as a tool that can help and advise about the doneness degree of your meat, when direct temperature measurement is not possible or not effective," Fedorov says.

More information: Fedor S. Fedorov et al, Detecting cooking state of grilled chicken by electronic nose and computer vision techniques, *Food Chemistry* (2020). DOI: 10.1016/j.foodchem.2020.128747

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