Data analysis in the kitchen: Modeling flavor networks to predict tasty ingredient combinations

July 12 2017

What's on the menu tonight? How about some roast beef with strawberry-, beer- and garlic sauce? Or perhaps something lighter based on tomatoes, apricots and whiskey gum? Gourmet chefs and foodies alike love to experiment in the kitchen and come up with new flavor combinations, and recent research is taking the science of combining ingredients to a whole new—computable—level. New research published in *Frontiers in ICT* suggests and analyses a possible new principle behind ingredient mixing in traditional cuisines—the food-bridging hypothesis - and compares it to the previously suggested food-pairing hypothesis, in order to examine what data driven graphical modelling can tell us about tasty ingredient combinations.

The food-pairing hypothesis was first suggested by the chef Heston Blumenthal and his friend François Benzi, when Blumenthal famously discovered the surprisingly delicious combination of caviar and white chocolate. "The food-pairing hypothesis suggests that if two ingredients share important flavor compounds, there is a good chance that they will result in a tasty combination," explains Dr Tiago Simas (University of Cambridge, UK). "In our article we suggest and analyze a new hypothesis: food-bridging. It is different from food-pairing, and opens the possibility of better understanding possible mechanisms behind mixing ingredients in a recipe. Whereas food-pairing intensifies flavor by combining ingredients with similar chemical compounds, food-bridging smoothes the contrast between the ingredients."

In their study, the research team analyzed food-bridging and compared it to food-pairing by creating a graphical model using data from seven different traditional cuisines. The model consists of a flavor network that relates 1,530 ingredients with 1,106 flavors, and shows how ingredients are related to each other according to the flavor compounds they have in common (food-pairing), and what is the shortest connection—or bridge—via one or more additional ingredients between two food types that have a low affinity (food-bridging). The study found that the flavor network was 72,6% semi-metric, meaning that there were a lot of possible paths to combine ingredients without a strong direct flavor affinity.

The researchers also found clear regional clusters that could be divided up in four classes depending on how food-bridging and food-pairing are, or aren't, used in the different traditional cuisines included in the study:

1. Low food-pairing + low food-bridging: East Asian cuisines, which tend to use contrasted ingredients with respect to flavor, which results in a cuisine that contrasts several flavors.

2. Low food-pairing + high food-bridging: Southeast Asian cuisines. While these cuisines are similar to East Asian cuisines with respect to food-pairing since contrasted ingredients are used, they also smooth these contrasts to a larger extent with other ingredients that bridge the contrasts.

3. High food-pairing + low food-bridging: Southern-, Eastern- and Western European, as well as the North American cuisines. These cuisines tend to follow the food pairing with the direct intensification of flavors in a recipe, while avoiding contrasted ingredients.

4. High food-pairing + high food-bridging: Latin American cuisines, which tend to reinforce the intensity of flavor using both food-pairing

and food-bridging. In other words, these cuisines use both direct and indirect intensification of flavors in a recipe, reinforcing common flavors and smoothing contrasts between flavored contrasted ingredients.

"We may suggest several explanations for why, in this analysis, traditional cuisines cluster in this way," notes Dr Simas. "The clustering aligns well with a geopolitical distribution. These cuisines may be driven by particular geographical weather and resource constrains as well as political trade in goods, which may influence the different styles of cuisine analyzed in our study. In general, we may observe these results that there is a dichotomy; with ingredients that are less suited to food-pairing tending to use the food-bridging mechanism, and vice-versa. Food-pairing and food-bridging are different hypotheses that may describe possible mechanisms behind the recipes of traditional cuisines." These results bring a new, more nuanced, perspective on food-pairing and introduces food-bridging as a new principle behind cooking and flavor mixing. Moreover, the mathematical representation of food-bridging—semi-metricity—could also be applied to other aspects of cooking such as texture and color, to make scientifically driven predictions about successful ingredient combinations. Bringing data analysis into the kitchen might just be the thing to make cooking and ingredient mixing feel like a piece of cake.

This research is part of a Frontiers Research Topic—a collection of articles—"Data in the Food Pipeline"

More information: Tiago Simas et al, Food-Bridging: A New Network Construction to Unveil the Principles of Cooking, *Frontiers in ICT* (2017). DOI: 10.3389/fict.2017.00014

Provided by Frontiers