Flavor network and the principles of food pairing

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(2011)
Outline

- Flavor Network
- Applications
  - Food Pairing Hypothesis
  - Regional Cuisines
  - FPH in Medieval Times
- Limitations
- Conclusions
Food scientists have linked ingredients with flavor compounds

Contains: 381 ingredients and 1,021 flavor components
What questions can the flavor network answer?
Question 1: Food Pairing

**Food Pairing Hypothesis**

Ingredients sharing flavor components are more likely to taste well together than ingredients that do not.
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**Uses:**
- Learn why foods taste good
- Food science
- Search for novel food combinations: white chocolate and caviar, chocolate and blue cheese

**Reformulate with math:** Are ingredient pairs in recipes strongly connected in the flavor network?
Testing the Food Pairing Hypothesis

- 56,498 recipes from:
  - American sources *epicurious.com* and *allrecipes.com*
  - Korean source *menupan.com*
- Recipes grouped into distinct regions
Number of shared compounds, $C_i$, in recipe $R$ with $n_R$ ingredients

\[ N_s(R) = \frac{2}{n_R(n_R - 1)} \sum_{i, j \in R, i \neq j} |C_i \cap C_j| \]

Real examples:
- Mustard Cream Pan Sauce: chicken broth, mustard, cream $\rightarrow N_s(R) = 0$
- Sweet and Simple Pork Chops: pork, apples, cheddar $\rightarrow N_s(R) = 60$

For each category, compared mean number of shared compounds in recipes ($N_s^{real}$) with the mean number in 10,000 randomly constructed recipes ($N_s^{rand}$)

\[ \Delta N_s = N_s^{real} - N_s^{rand} \]

\[ N_s^{real} = \sum_R N_s(R)/N_c \]
Food Pairing Hypothesis: Results

North American recipes tend to share more compounds, East Asian share less.
Question 2: Regional Cuisines

Are specific compounds/ingredients responsible for regional differences?

\[
\chi_i^c = \left( \frac{1}{N_C} \sum_{i \in R} \frac{2}{n_R(n_R - 1)} \sum_{j \neq i, (j, i) \in R} |C_i \cap C_j| \right) - \left( \frac{2f_i}{N_C < n_R} \sum_{j \in c} \frac{f_j |C_i \cap C_j|}{\sum_{j \in c} f_j} \right)
\]

Positive \(\chi_i\) values increase the number of shared compounds.
Flavor Pairing in Medieval European Cuisine:
A Study in Cooking with Dirty Data

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(2013)
Was the Food Pairing Hypothesis true during Medieval Times?

Recipe Database:
- 4,133 recipes from 1300 – 1615
- 25 source texts from England, France, Germany and Italy
- Manually placed ingredients into 391 equivalence groupings
- 386 different ingredients

Compound Databases:
- Volatile Compounds in Food (VCF) - more complete dataset
- Fenaroli’s Handbook of Flavor Ingredients - sparser
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FPH true with Fenaroli, not with VCF
Columbian Exchange (1492) resulted in variety of new foods

Source: thecolumbianexchange.weebly.com
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Conjecture: Western cooks maintained FPH after Columbian Exchange
Limitations and Conclusions

Limitations:

- Flavors depend on method of cooking
- Does not account for texture, color, sound, or temperature
- Some ingredients have structural role (eggs)
- Does not include flavor compound concentration
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Additional Applications:

- Searching for similar recipes
- Recipe recommender
- Ingredient recommender
- Study cultural differences and mixing of cultures
- Study historical culinary trends