

The molecular essence of Indian cuisine



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Cooking is alchemy



Cooking: Central to evolution of human brain

Cooking is the essence of being human



'Catching Fire—How cooking made us human' by Richard Wrangham

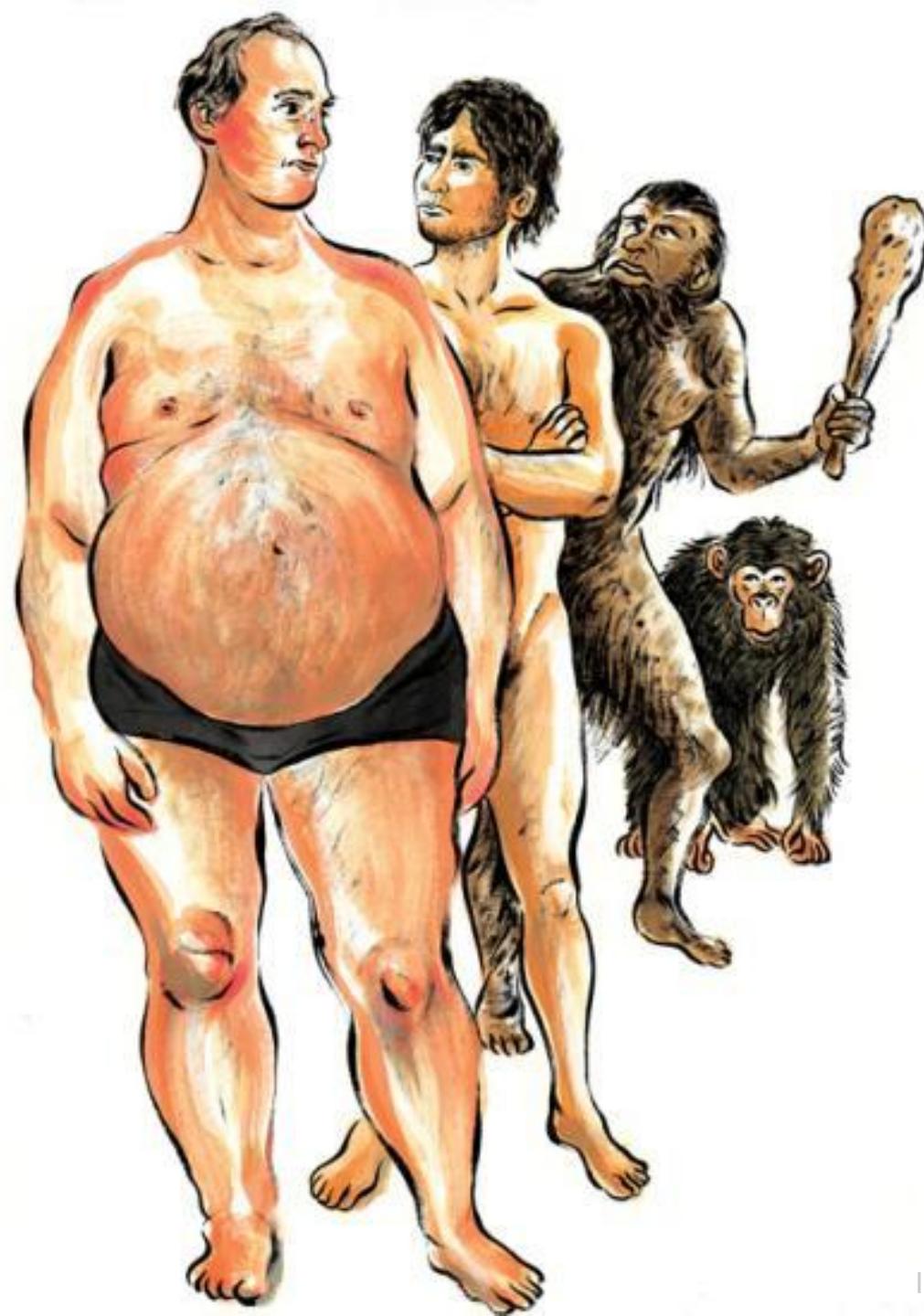


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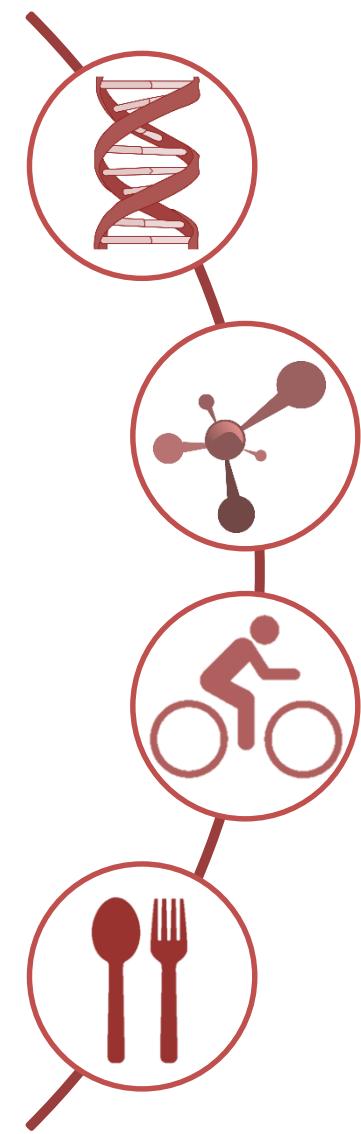
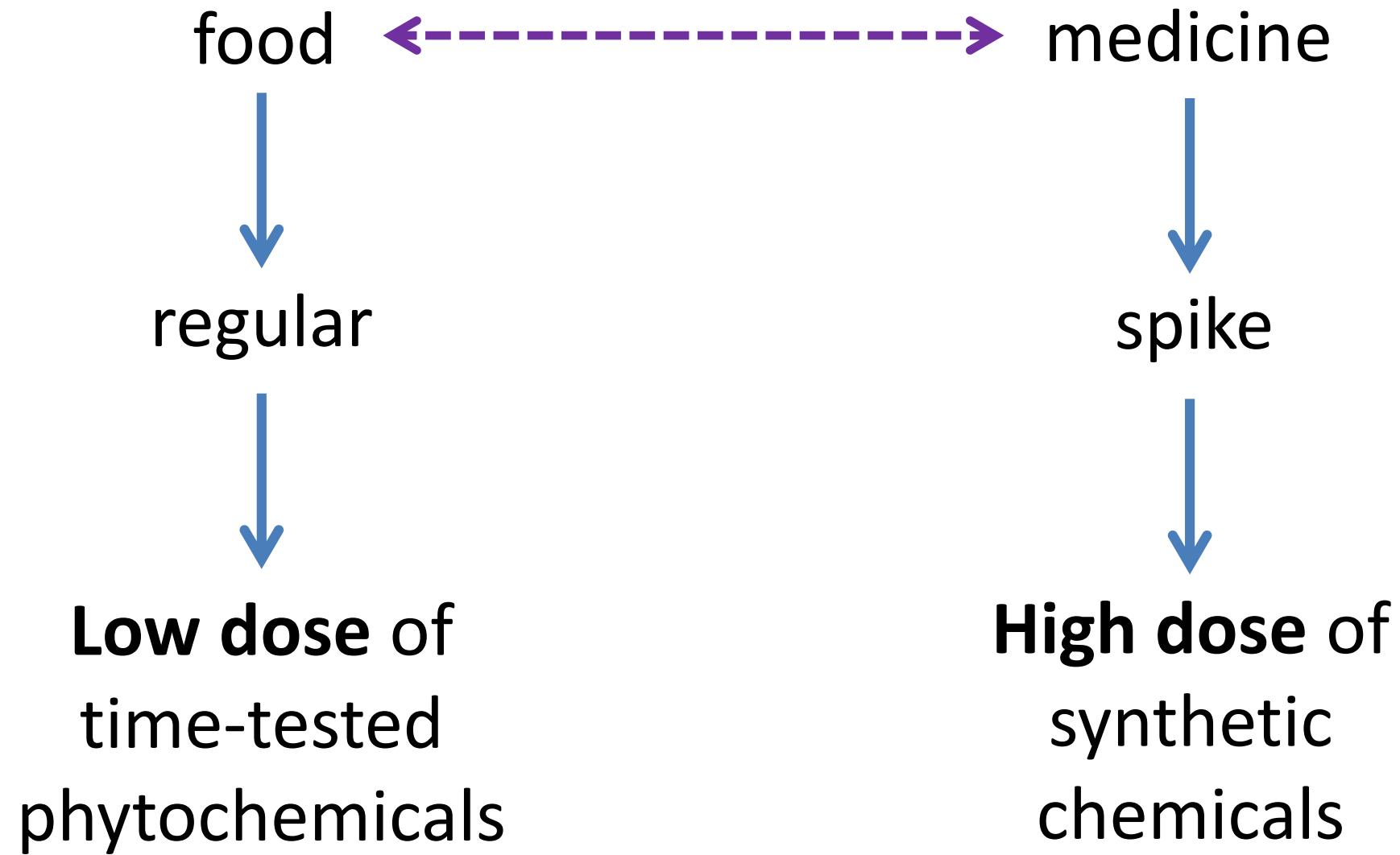


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diabetes
cancer



Why do we eat what we eat?

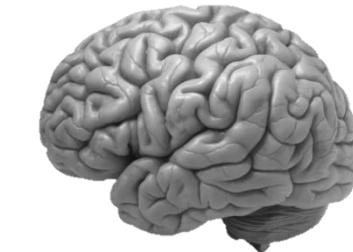
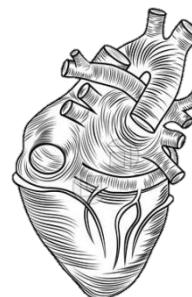
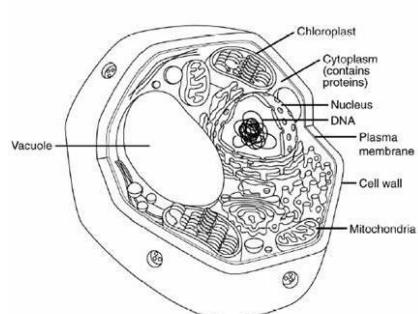
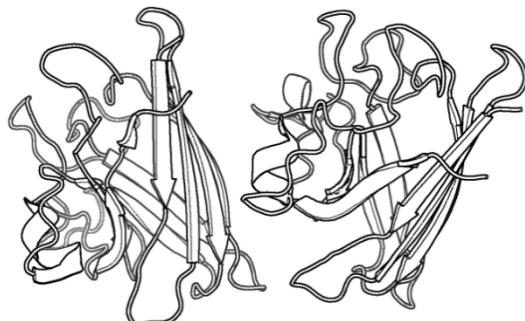
Why do we combine ingredients
in our recipes the way we do?



Recipe as a Complex System

A system comprising of large number of sophisticated functional elements, intricately connected with each other to perform specific tasks, which otherwise can not be executed by subsets of the system.

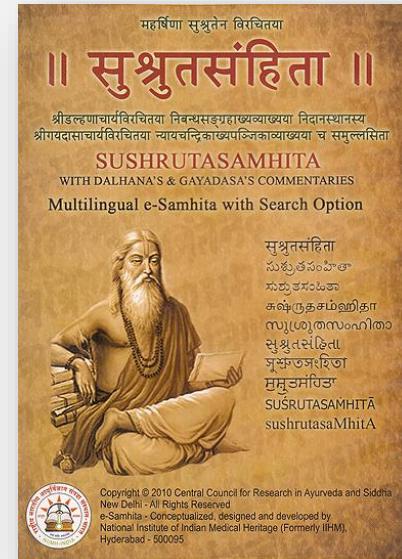
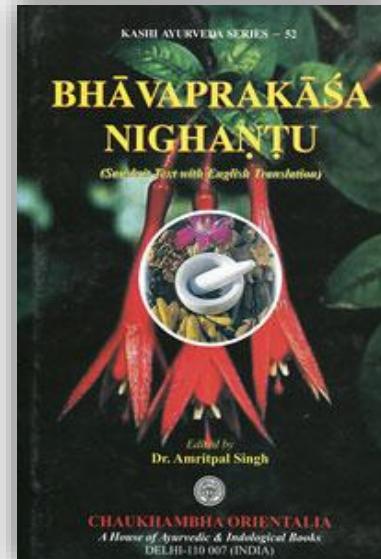
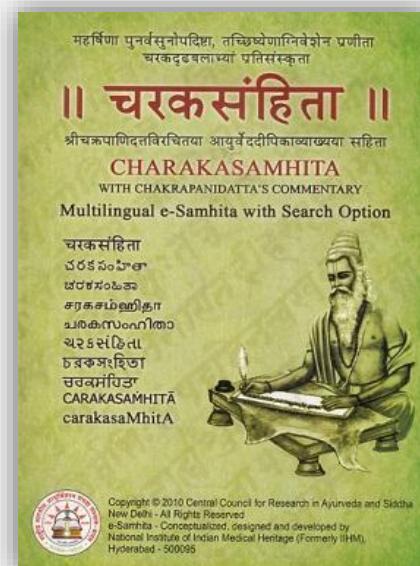
SUM OF PARTS
– IS NOT THE SAME AS –
THE WHOLE



अत्रं वै प्राणः

- India has a culinary history of **health-centric dietary practices** aimed at disease prevention and promotion of health.
- **Food as a medicine:** Traditionally, food has been treated as a medicinal agent in the Indian subcontinent.

Charaka Samhitā (चरक संहिता) Susruta Samhitā (सुशृत संहिता) Bhāvaprakāśa Nighaṇṭu (भावप्रकाश निघण्टु)



:: Data ::

well tested[↑]

&

well tasted



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Just Added

44 new recipes

View all new recipes

2543 recipes, 194 ingredients, From 8 sub-cuisines— Bengali, Gujarati, Jain, Maharashtrian, Mughlai, Punjabi, Rajasthani, South Indian

Recipe Contest of the Month

Recipes Using Sesame Seeds (til)

[View contest archive....](#)

New Release



- Carrot and Spinach Soup
- Cucumber Cooler
- Rajma Cheese Paratha
- Aloo Paneer Chaat

Bright Vision! Green Garlic! Eat the Italian Way Soft and Fluffy Pancakes

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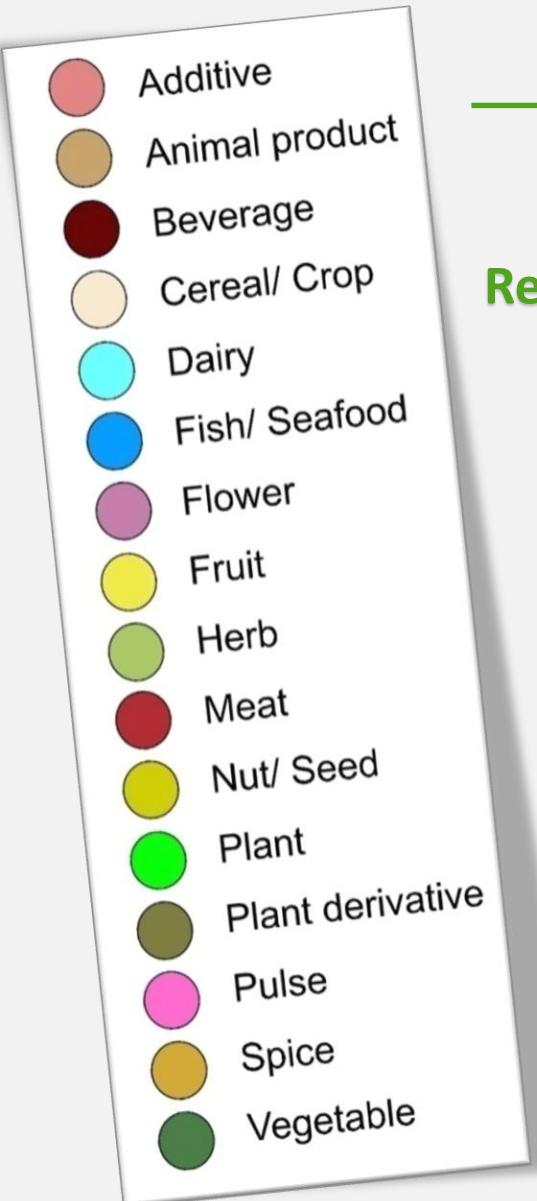
TARLA DALAL VOLUME XI ISSUE 4 NOV-DEC 2013 Rs.50
Cooking & more
Tarla Dalal Master of All Cuisines

Tribute to Tarla Dalal Master of All Cuisines

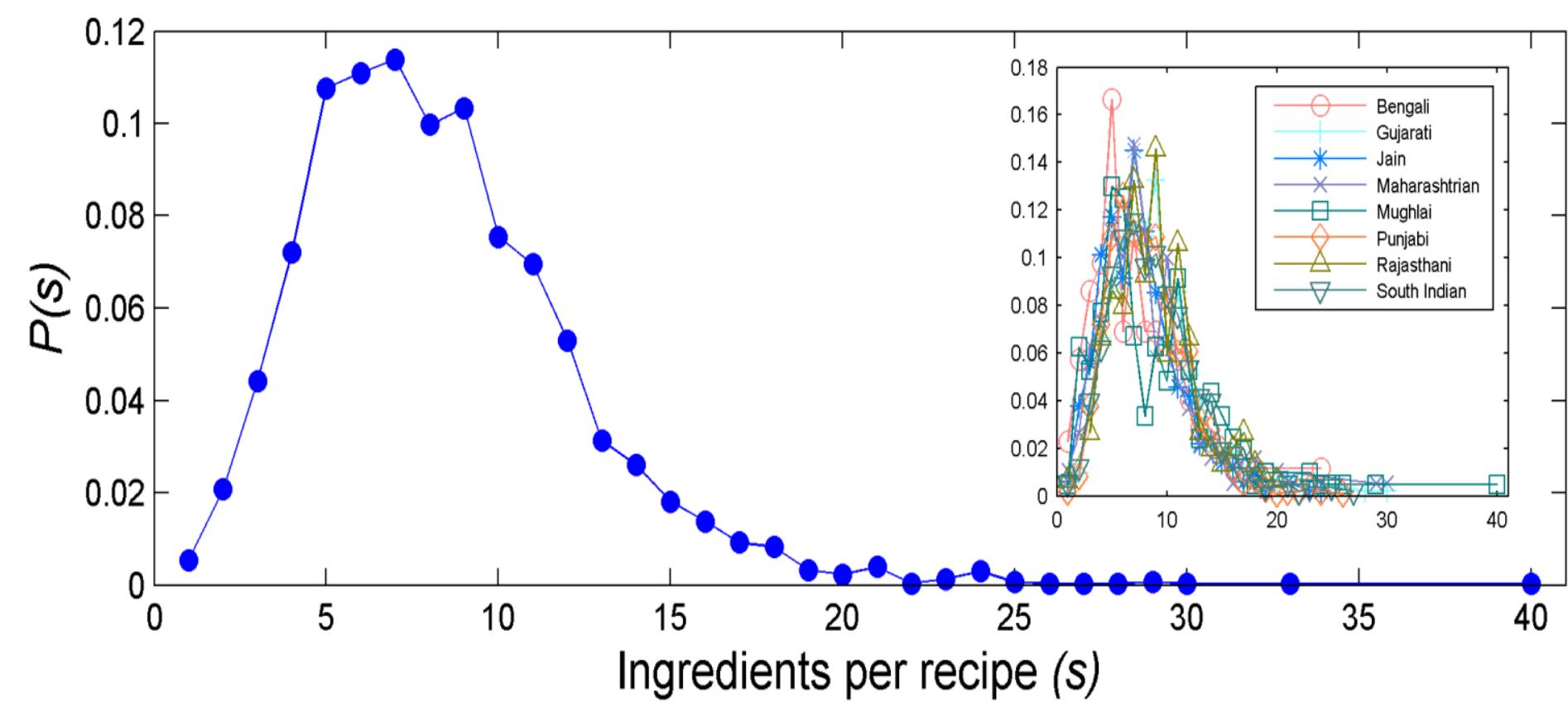
Recipes & Ingredients

2543 Traditional Indian Recipes (TarlaDalal)

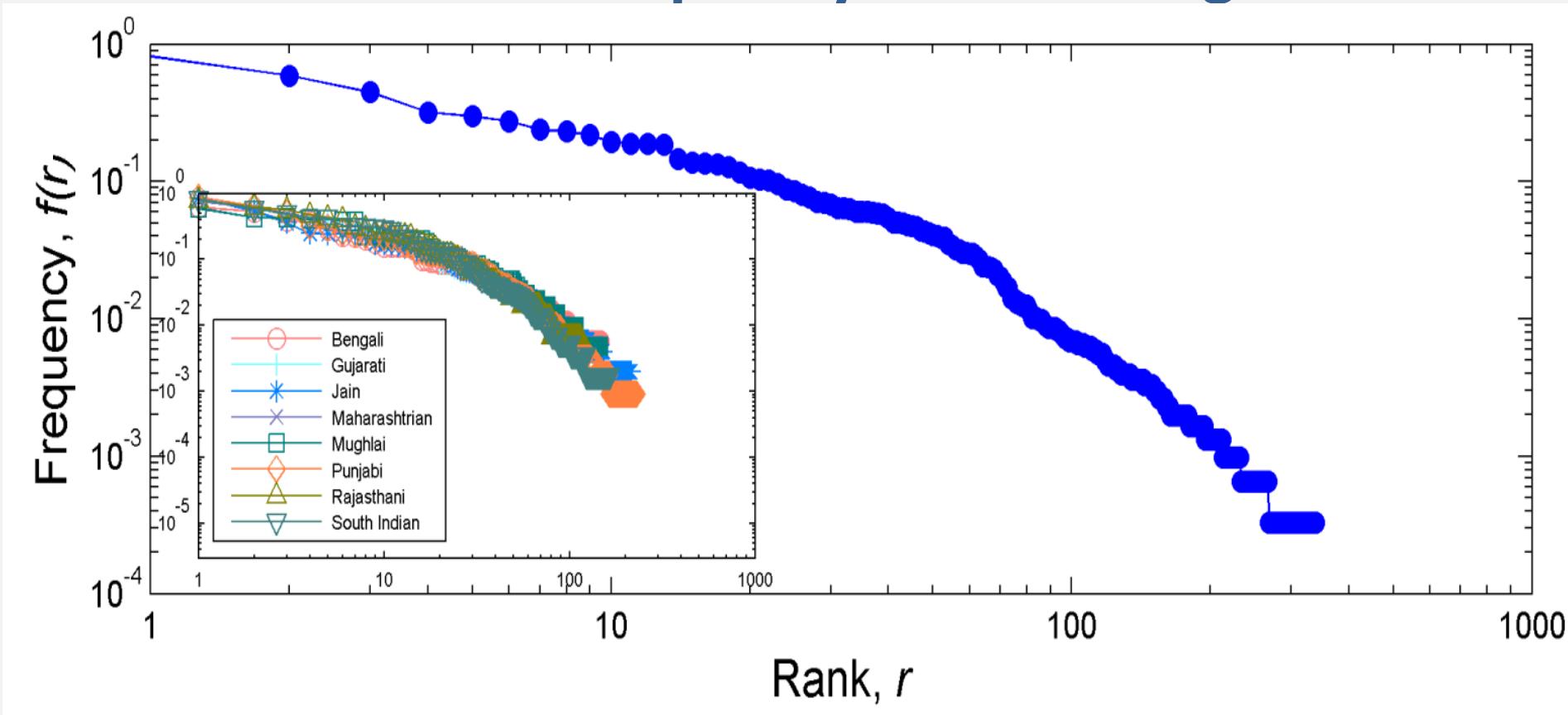
Regional cuisines: Bengali, Gujarati, Jain, Maharashtrian, Mughlai, Punjabi, Rajasthani, South Indian.



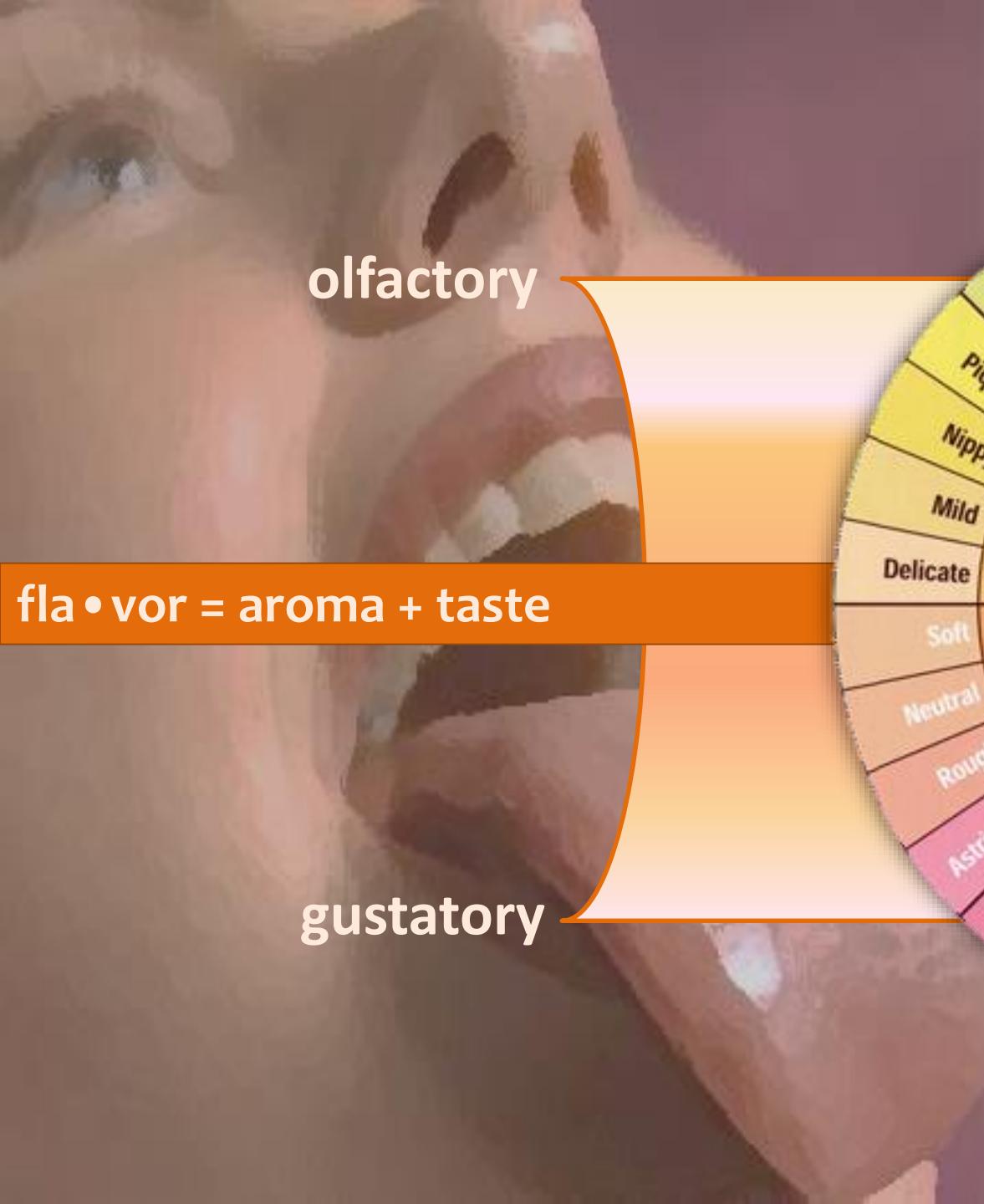
Indian cuisine: Recipe size statistics



Indian cuisine: Frequency of use of ingredients

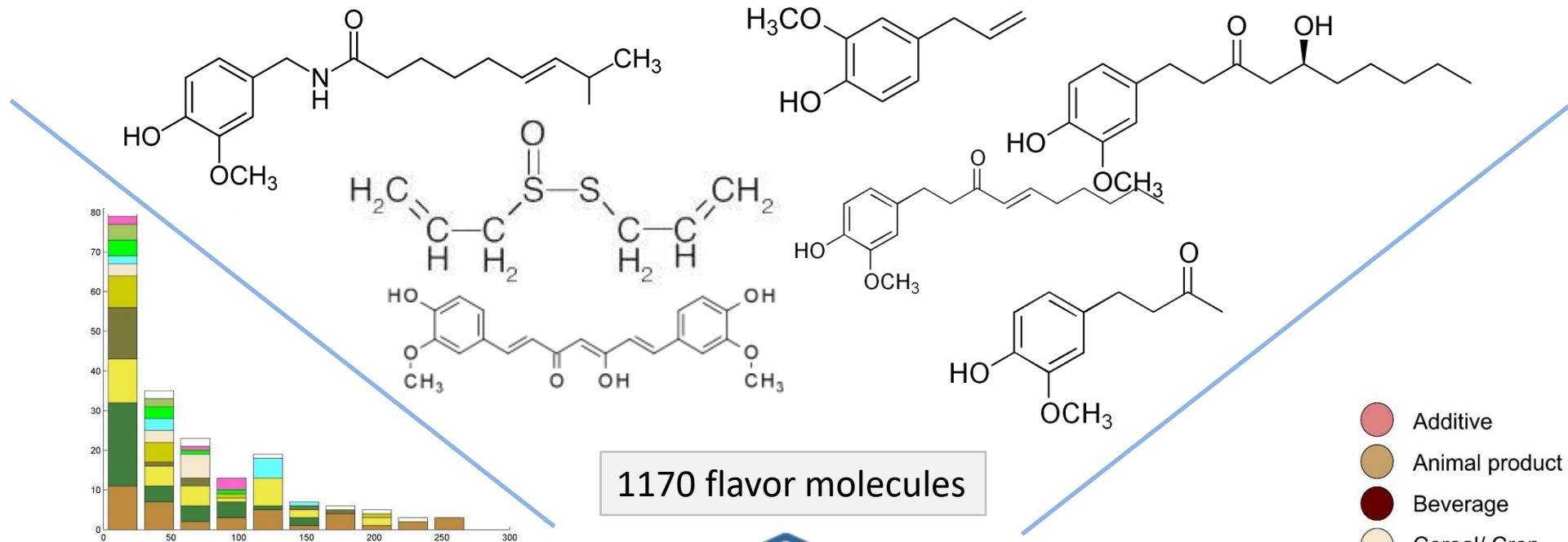


- Scale free distribution.
- Invariant across sub-cuisines.

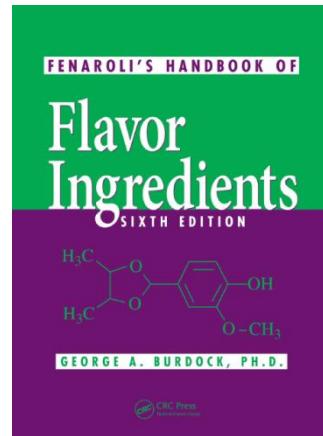


fla•vor = aroma + taste





PubChem



194 ingredients

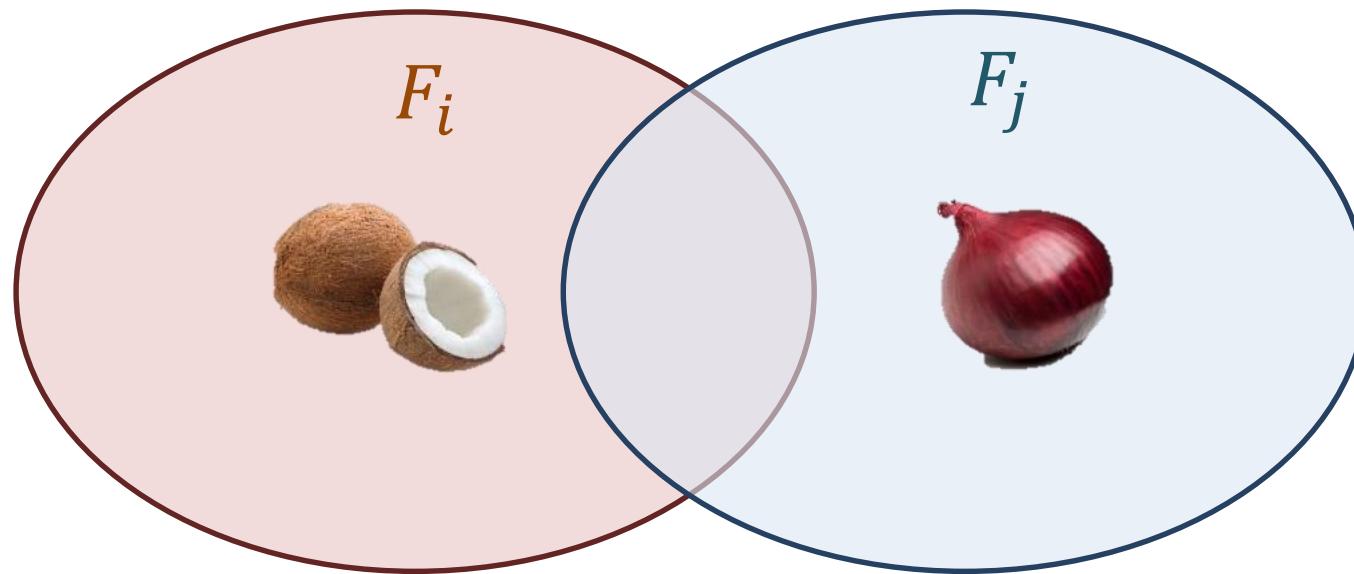


Ahn et. al, *Sci. Rep.*, 1, 196 (2011).

- Additive
- Animal product
- Beverage
- Cereal/ Crop
- Dairy
- Fish/ Seafood
- Flower
- Fruit
- Herb
- Meat
- Nut/ Seed
- Plant
- Plant derivative
- Pulse
- Spice
- Vegetable

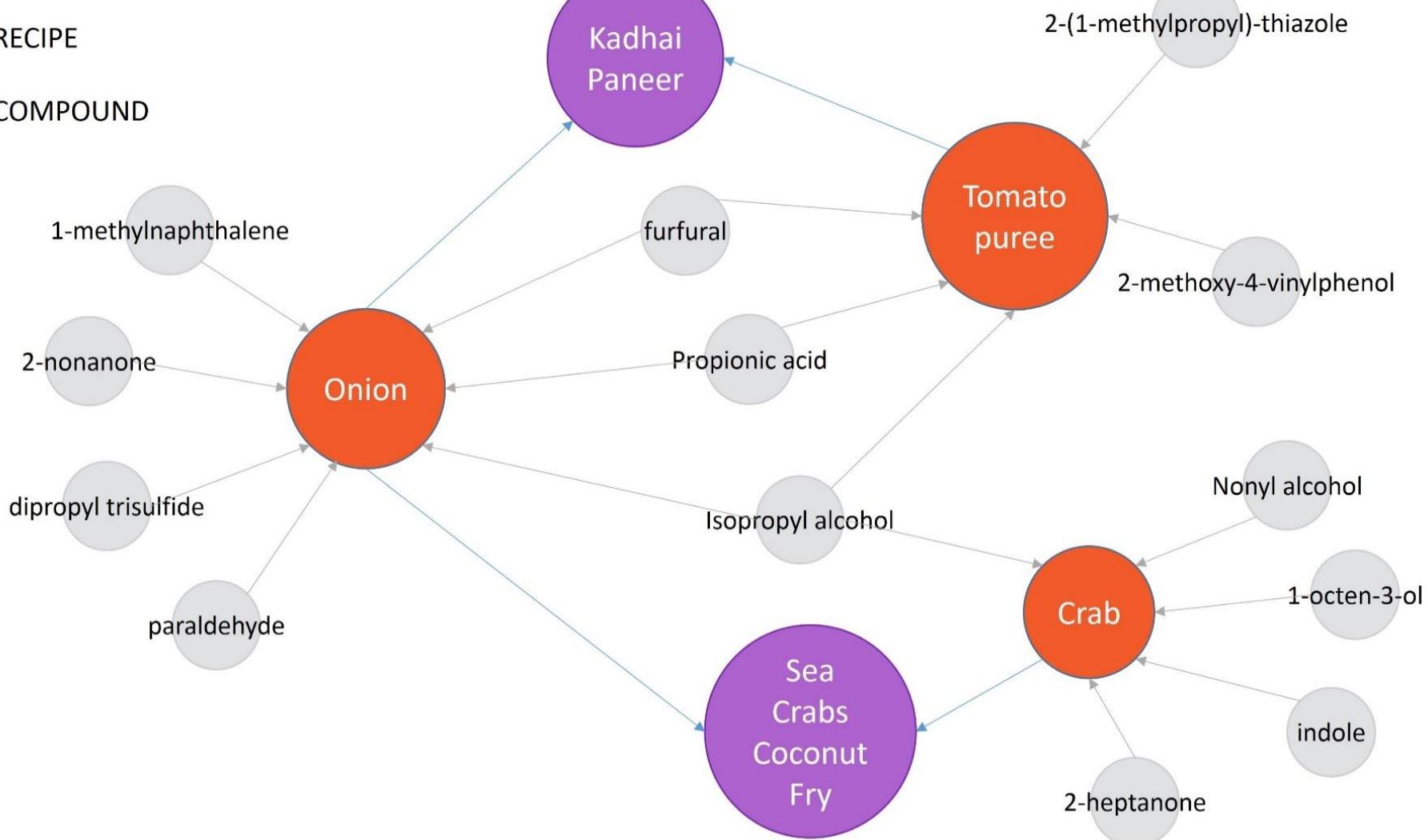
Food Pairing Hypothesis

Ingredients sharing flavor compounds are more likely to taste well together than ingredients that do not.

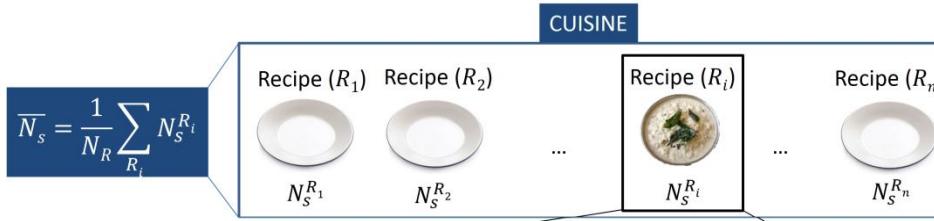
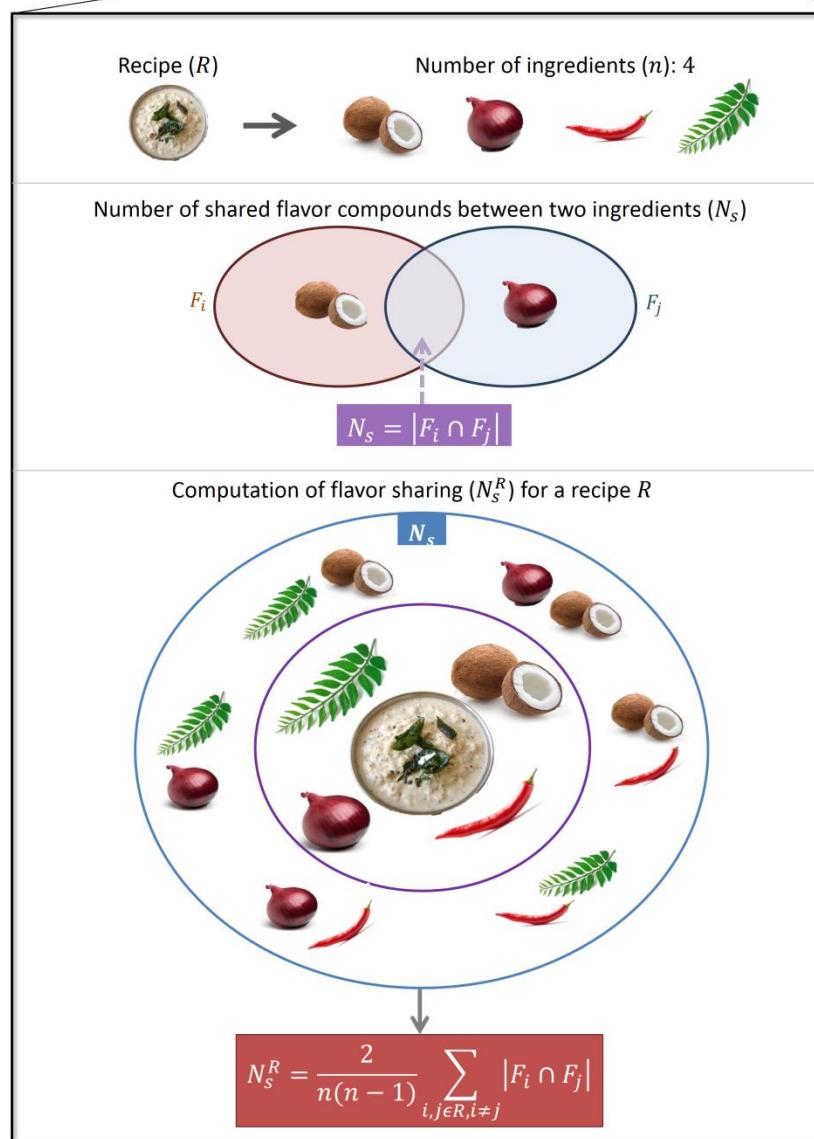


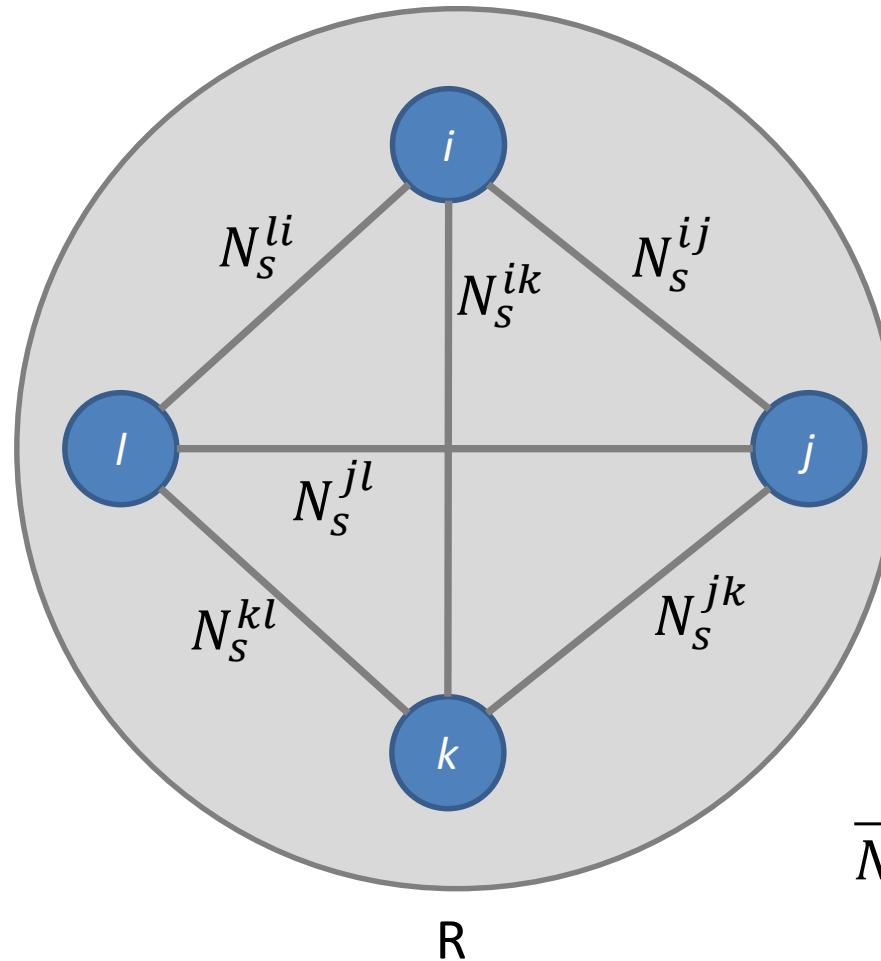
$$N_s = |F_i \cap F_j|$$

- INGREDIENT
- RECIPE
- COMPOUND



Food Pairing





N_s^{ij} Number of shared flavor molecules between ingredients i and j

$\overline{N_s^R}$ Average number of shared flavor molecules across all pairs of ingredients in the recipe R

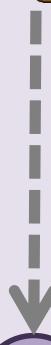
$\overline{N^{Cuisine}}$ Average number of shared flavor molecules across all recipes in a cuisine

Uniform Food Pairing

Western Cuisines

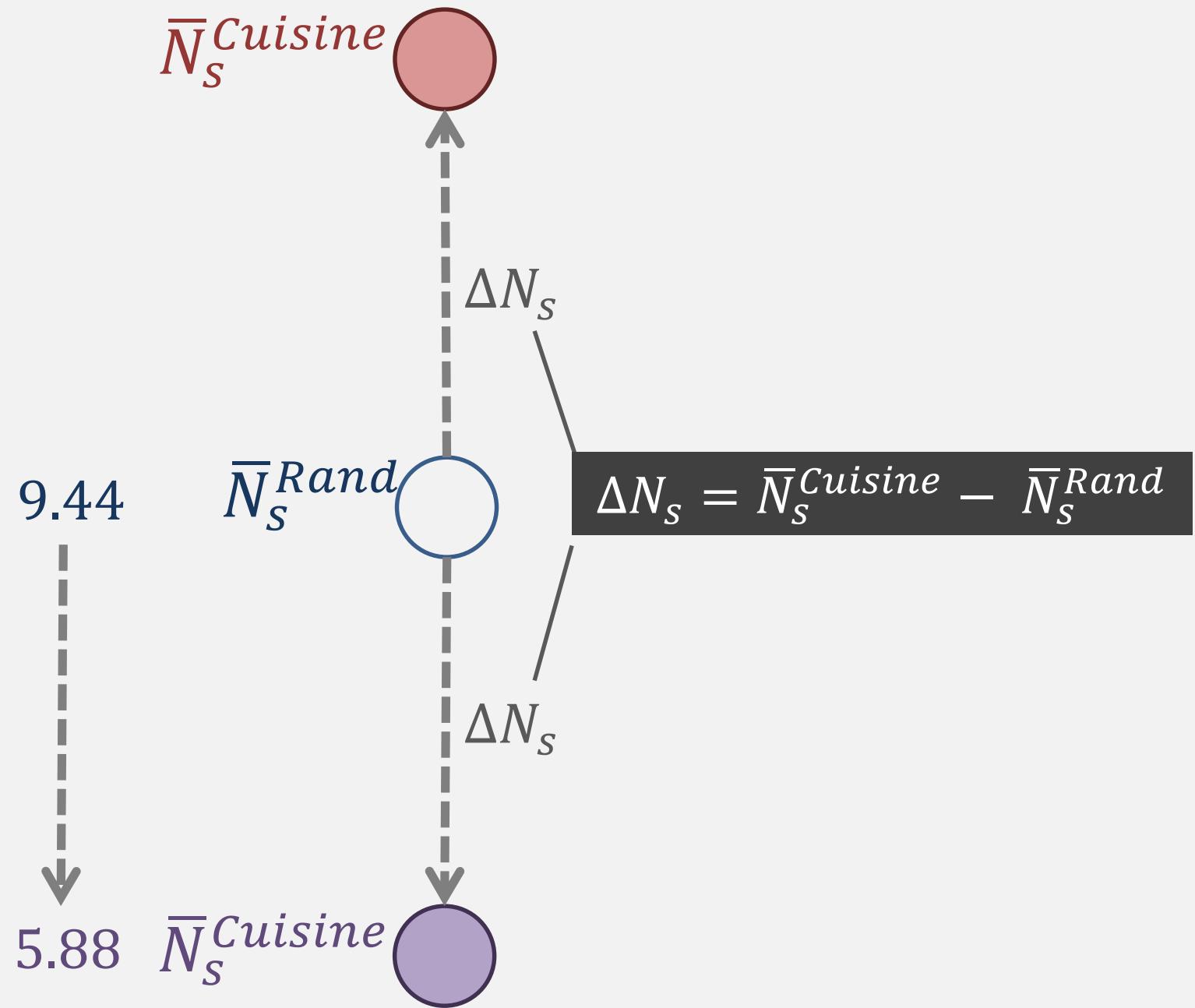


Random Cuisine



Indian Cuisine

Contrasting Food Pairing



**Indian cuisine is
characterized with
negative food pairing.**

**more the extent of flavor sharing between any
two ingredients, lesser their co-occurrence**

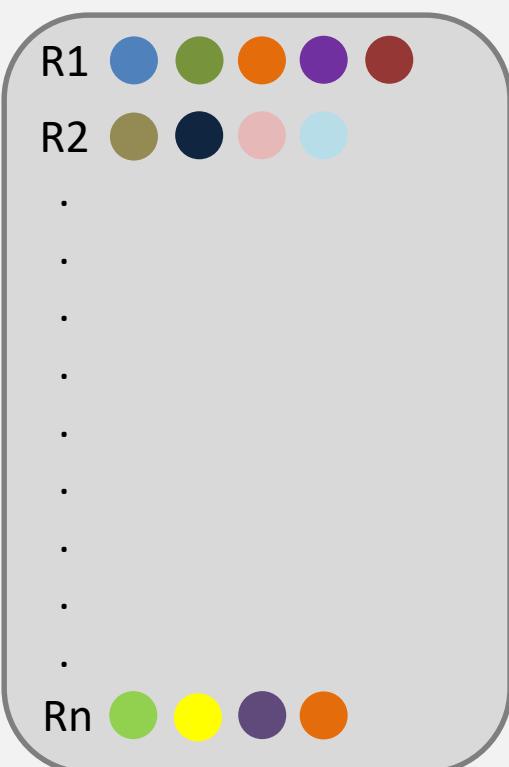


***Western cuisines have a
uniform blend of ingredients.***

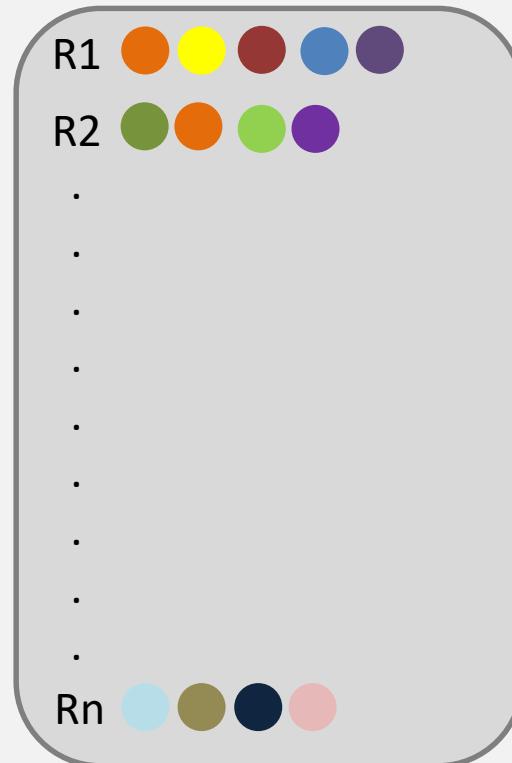
***Indian cuisine has a
contrasting blend of ingredients.***

How to create a random cuisine? (Strategy – 1)

- (1) Corresponding to every recipe, create its size-controlled randomized version by randomly sampling ingredients from the ‘Ingredients Basket’ (without replacement).
- (2) Having thus created ‘a randomized cuisine’, create a large number of such cuisines (say, 100) for statistical analysis.

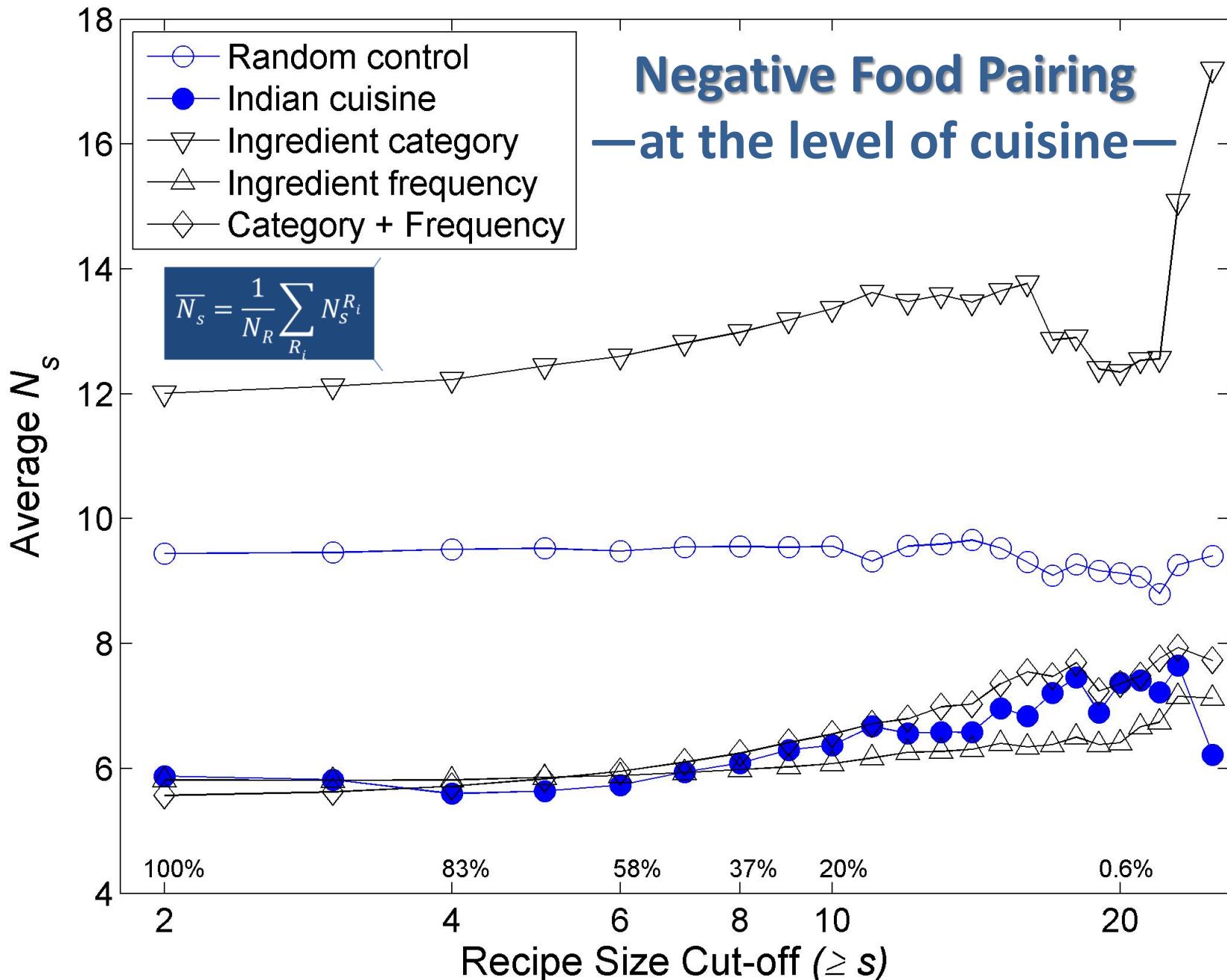


Randomize cuisine 1



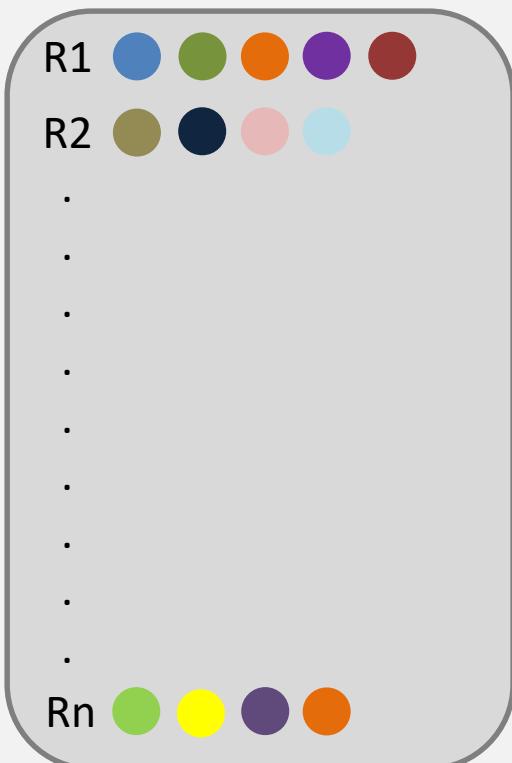
Randomize cuisine 100

Negative Food Pairing —at the level of cuisine—

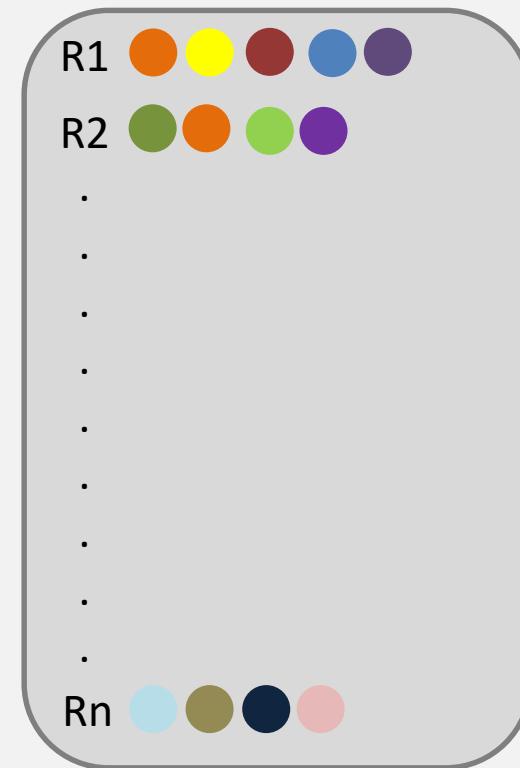


How to create a random cuisine by PRESERVING CATEGORY COMPOSITION?

- (1) Corresponding to every recipe, create its size-controlled randomized version by sampling ingredients from the ‘Ingredients Basket’ (without replacement) BY PRESERVING/MAINTAINING ITS CATEGORY.
- (2) Having thus created ‘a randomized cuisine’, create a large number of such cuisines (say, 100) for statistical analysis.



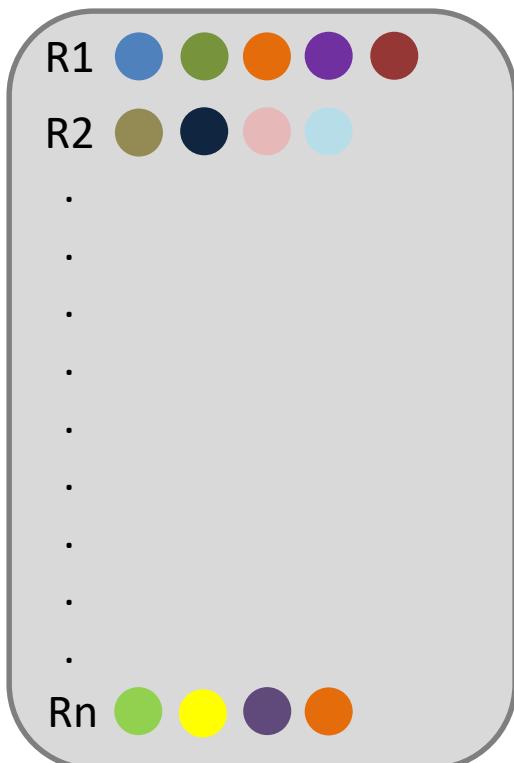
Randomized cuisine 1



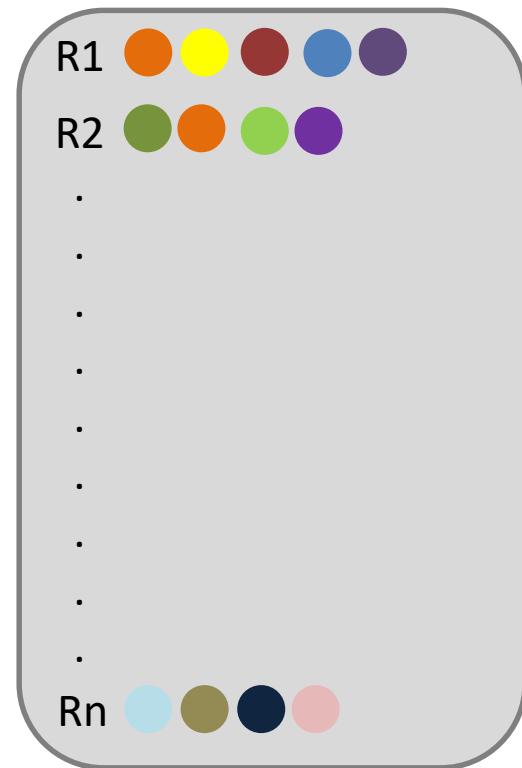
Randomized cuisine 100

How to create a random cuisine by PRESERVING INGREDIENT FREQUENCY?

- (1) Corresponding to every recipe, create its size-controlled randomized version by sampling ingredients from the ‘Ingredients Basket’ (without replacement) SUCH THAT INGREDIENTS ARE PICKED PROPORTIONAL TO THEIR FREQUENCY.
- (2) Having thus created ‘a randomized cuisine’, create a large number of such cuisines (say, 100) for statistical analysis.



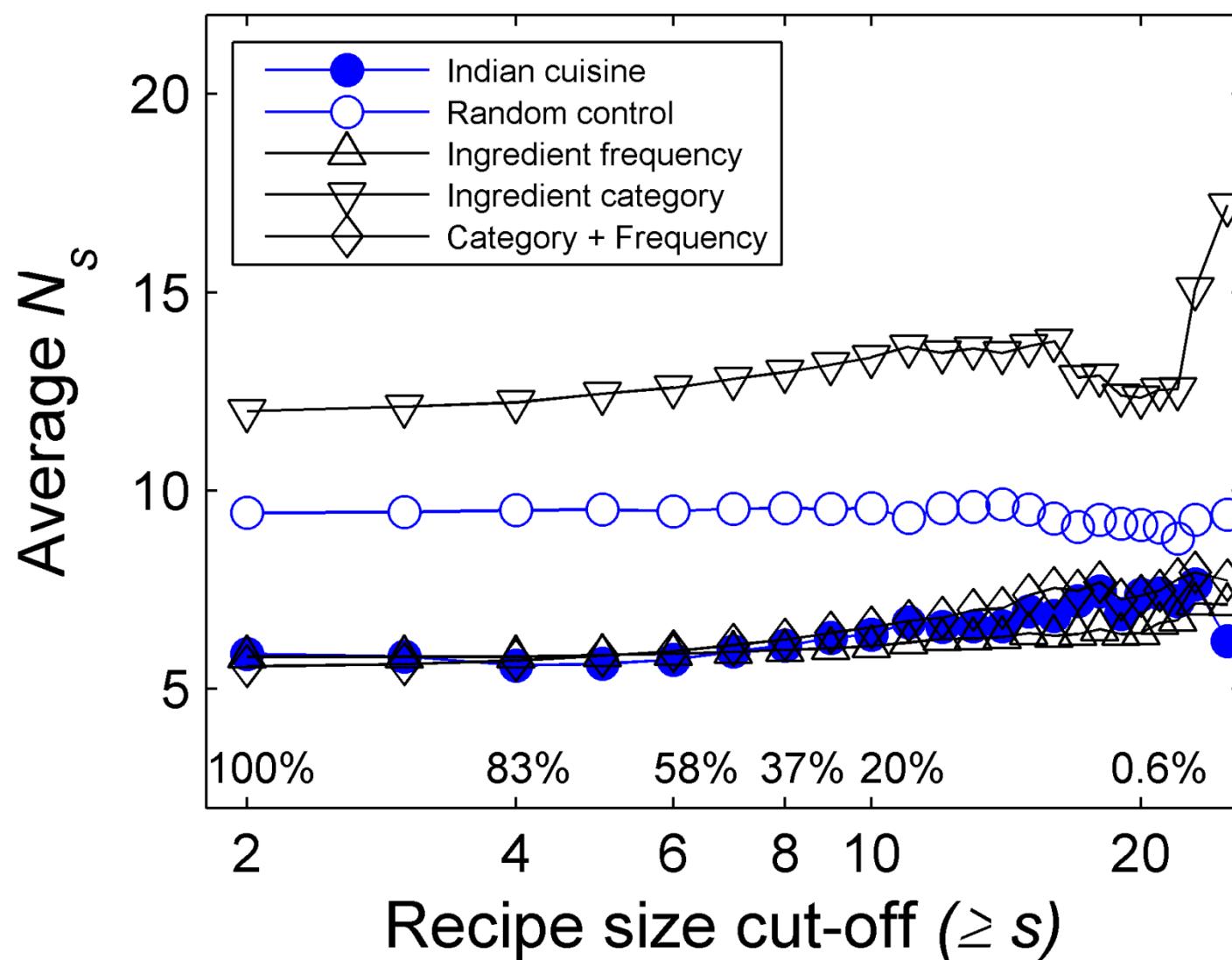
Randomized cuisine 1



Randomized cuisine 100

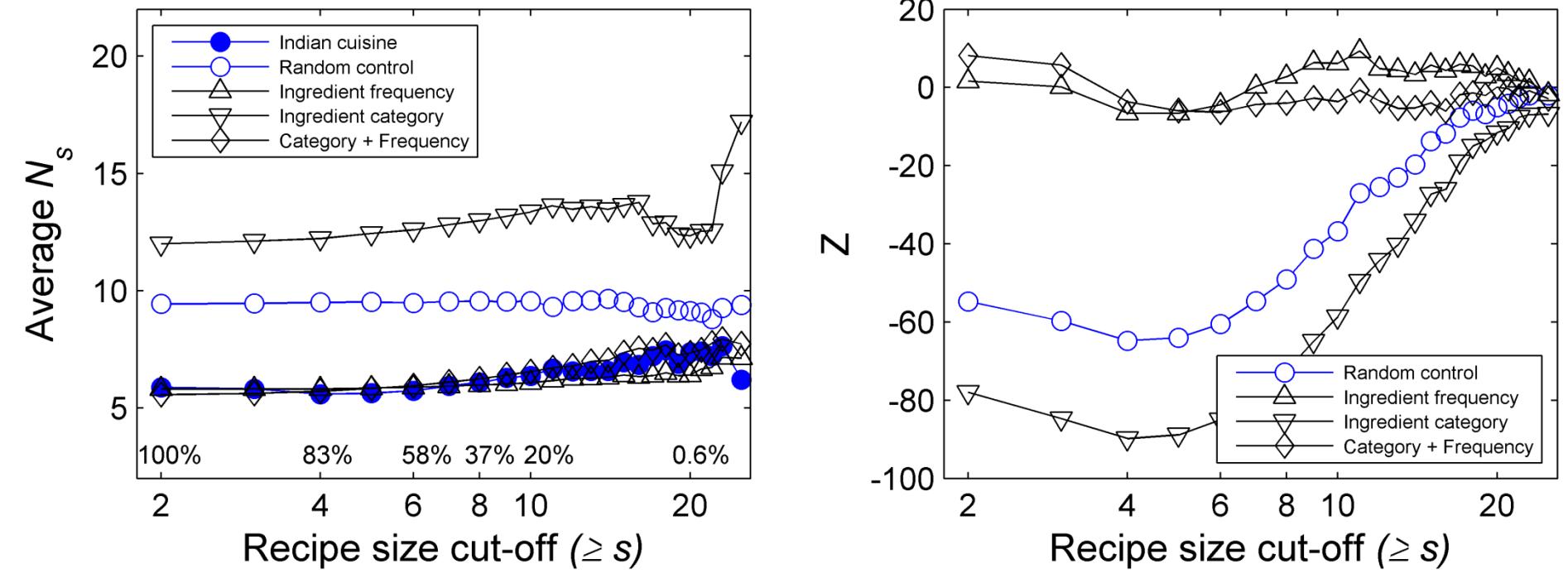
Negative Food Pairing

—at the level of cuisine—



Negative Food Pairing

—at the level of cuisine—

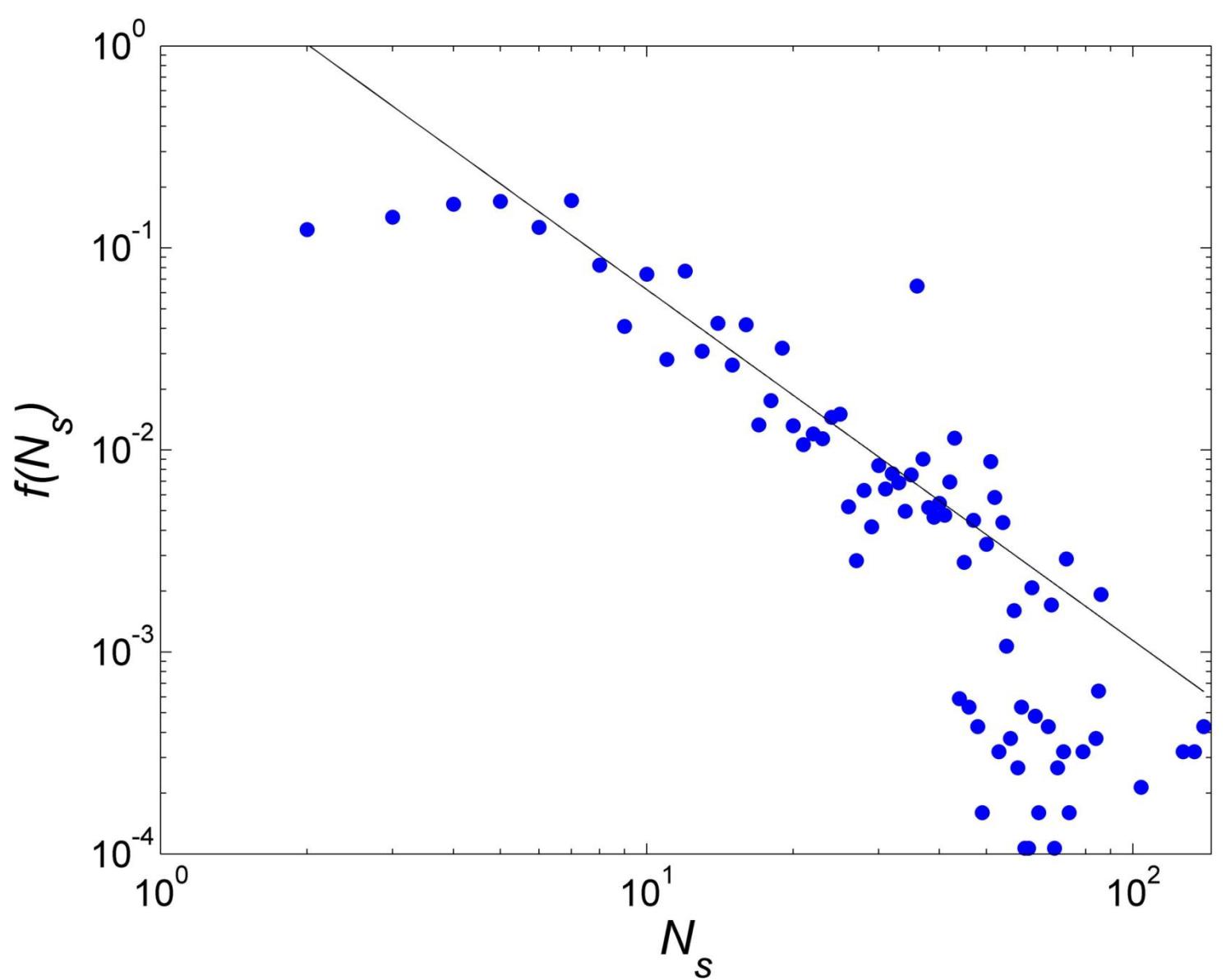


Number of recipes in
random controls: 20,000

$$Z = \sqrt{N_{Rand}} \frac{(\bar{N}_s^{IC} - \bar{N}_s^{Rand})}{\sigma_{Rand}}$$

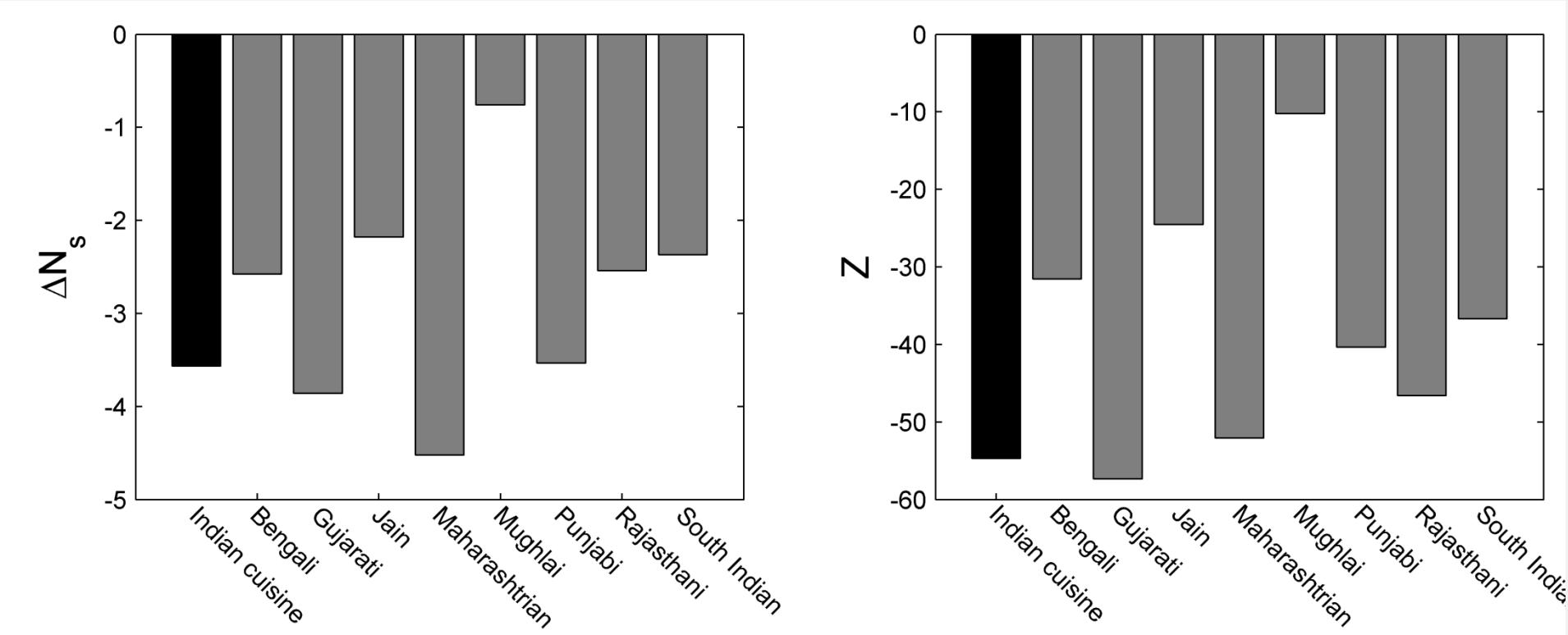
Negative Food Pairing

—at the level of ingredient pairs—

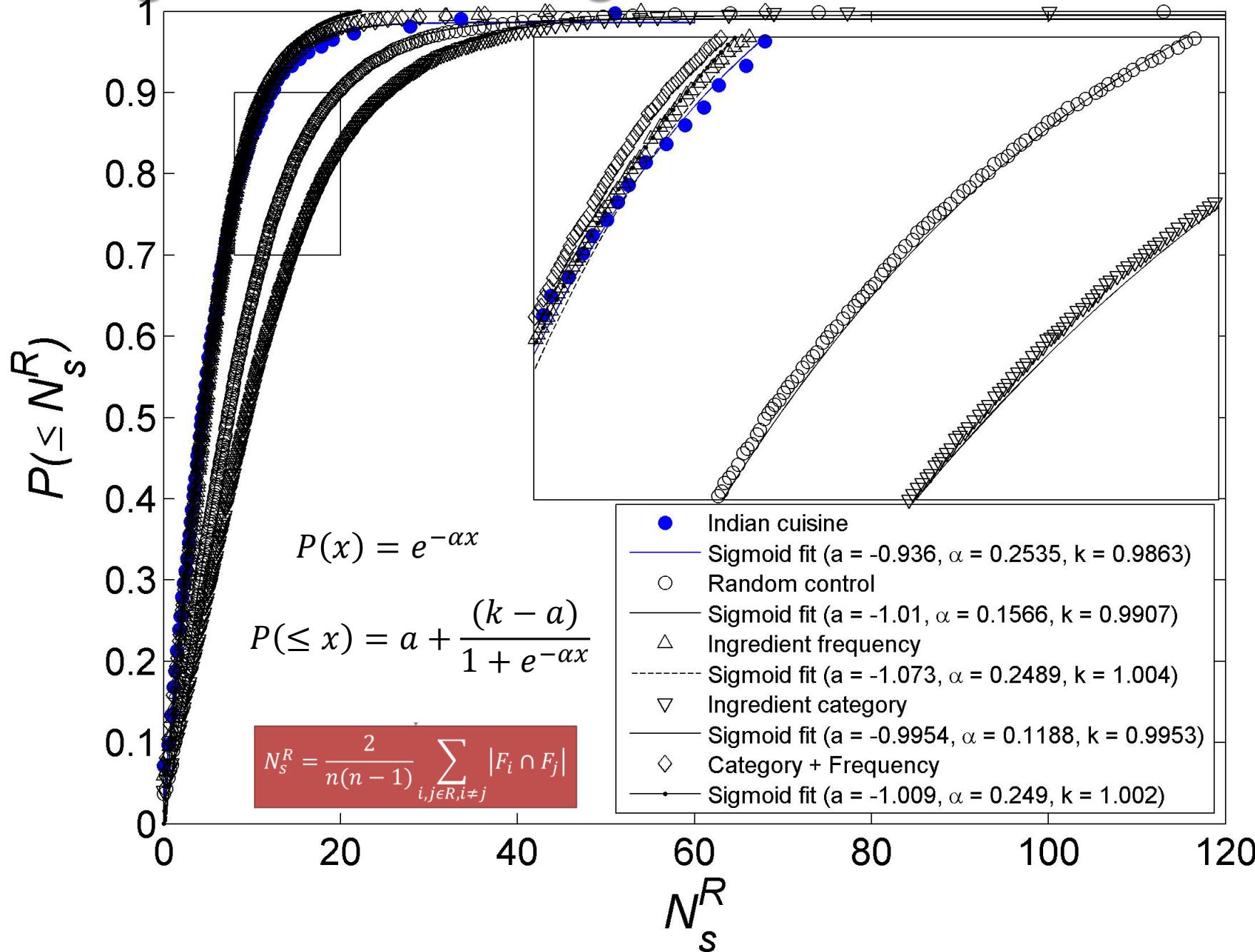


Negative Food Pairing

—at the level of sub-cuisines—



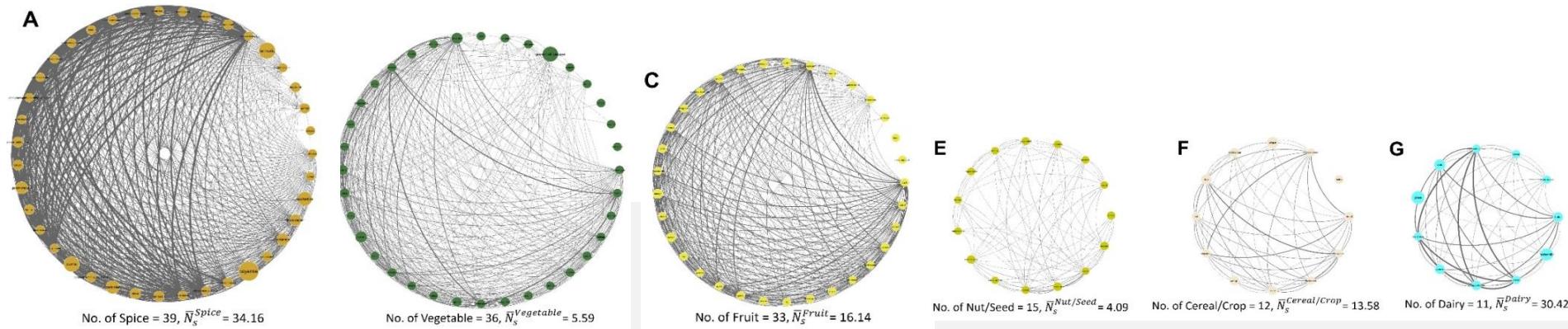
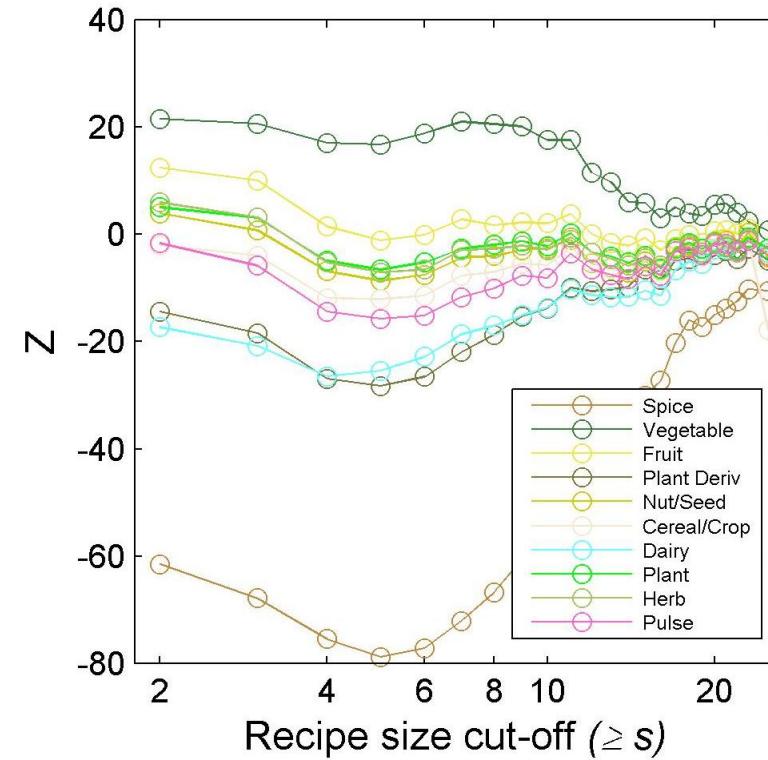
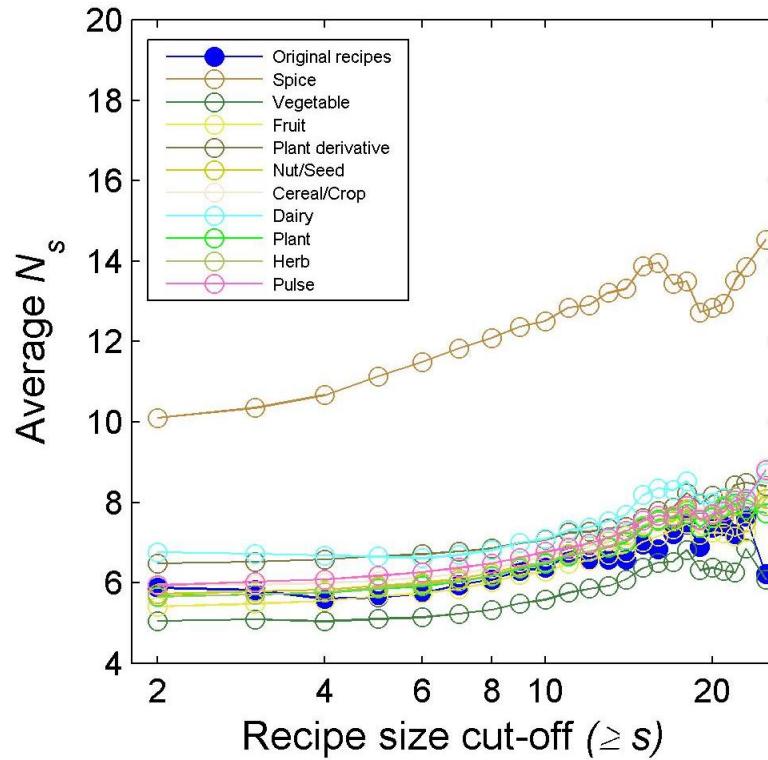
Negative Food Pairing —at the level of recipes—



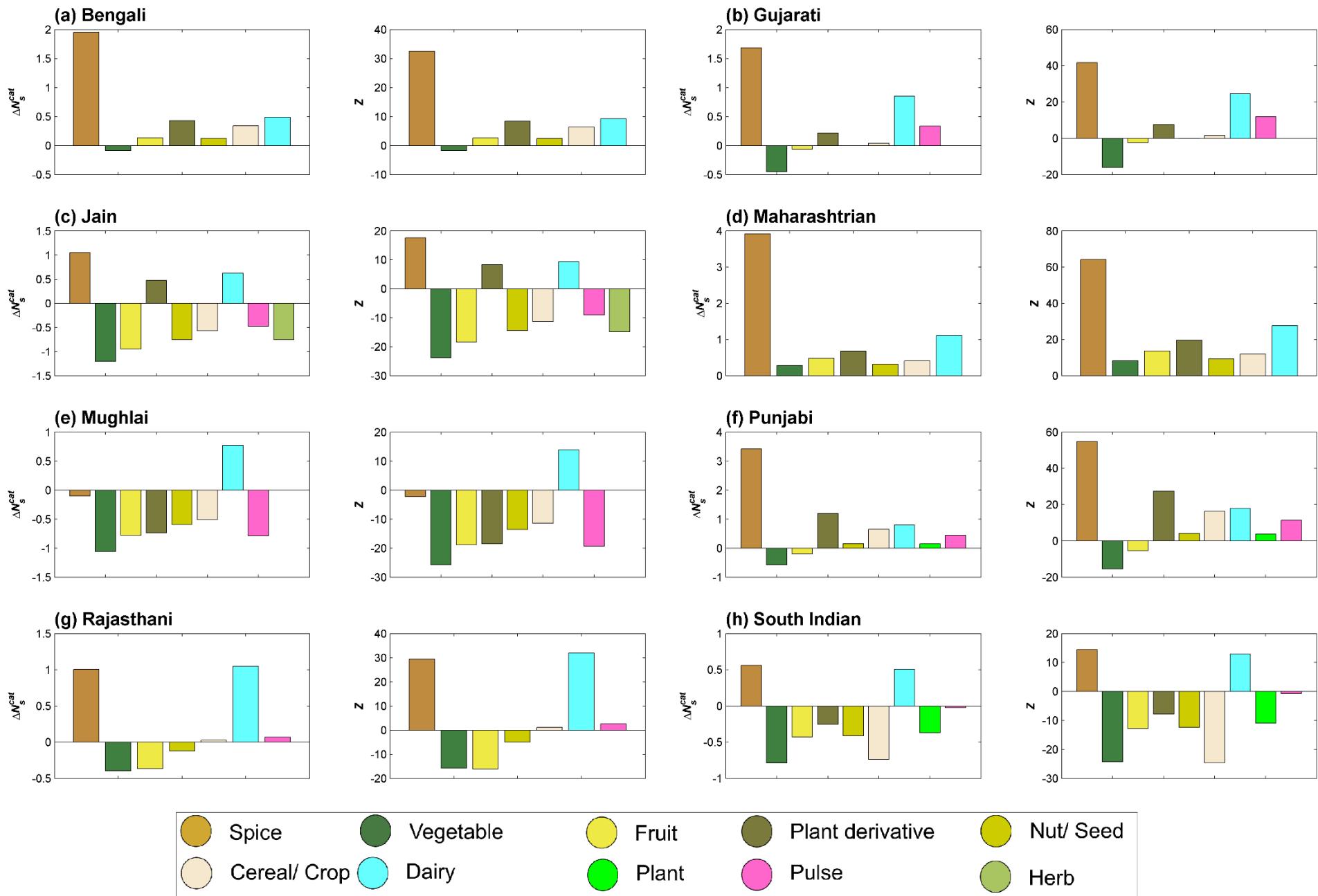
**Indian cuisine is
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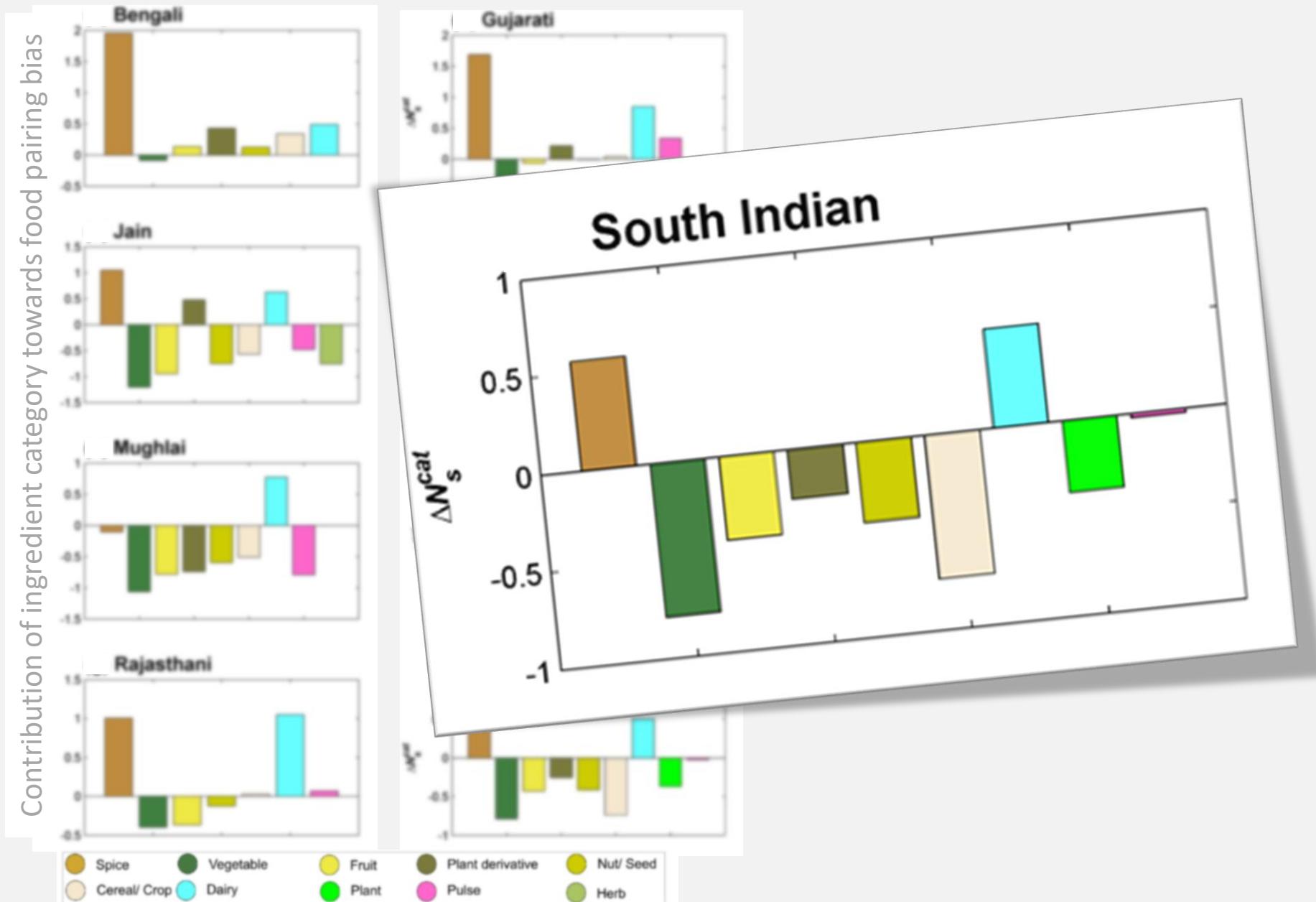
Spices are key to the food pairing in Indian cuisine



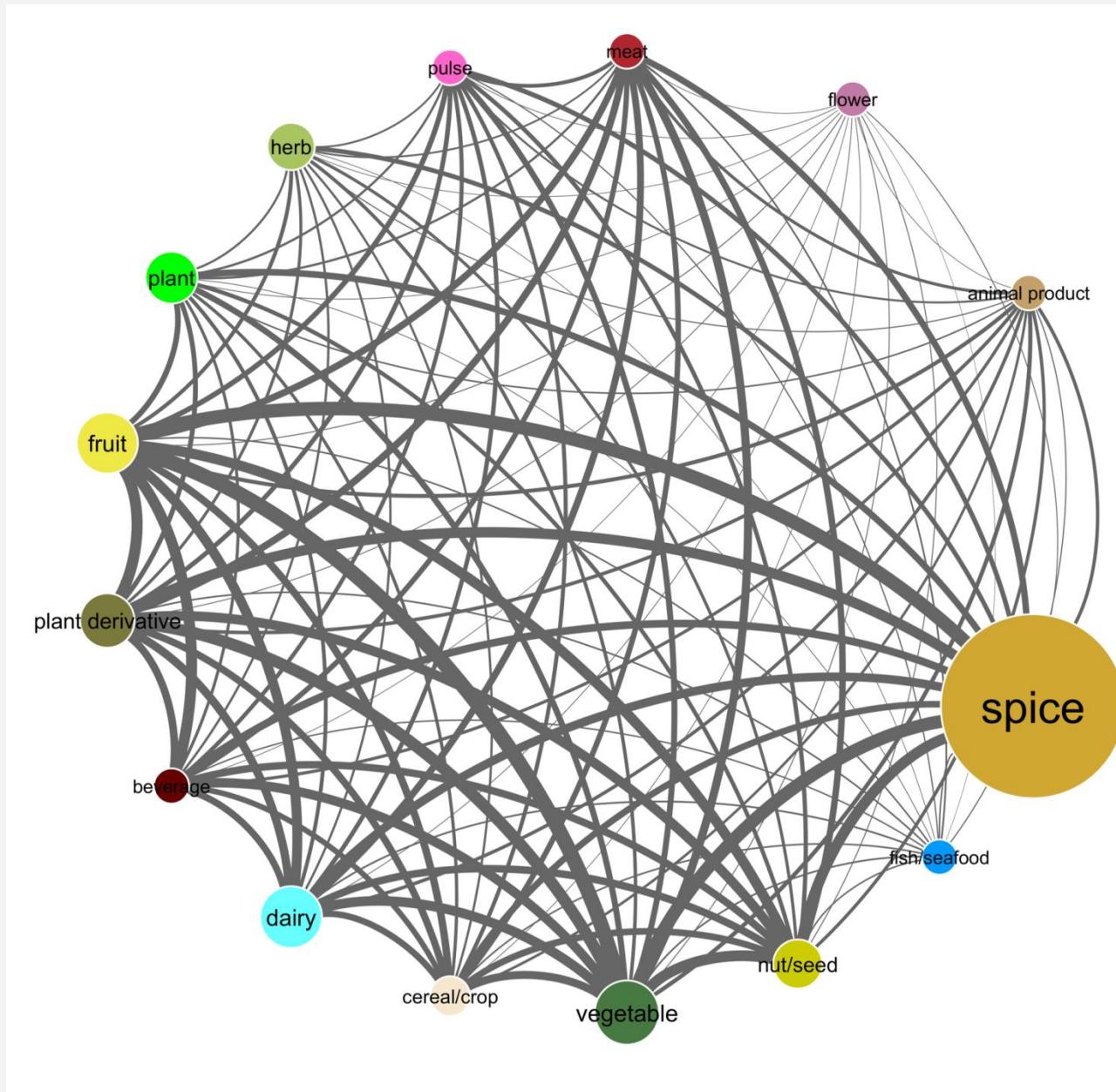
Culinary Fingerprinting of Regional Cuisines of India



Culinary Fingerprints of Regional Cuisines of India



Spices are key to the food pairing in Indian cuisine

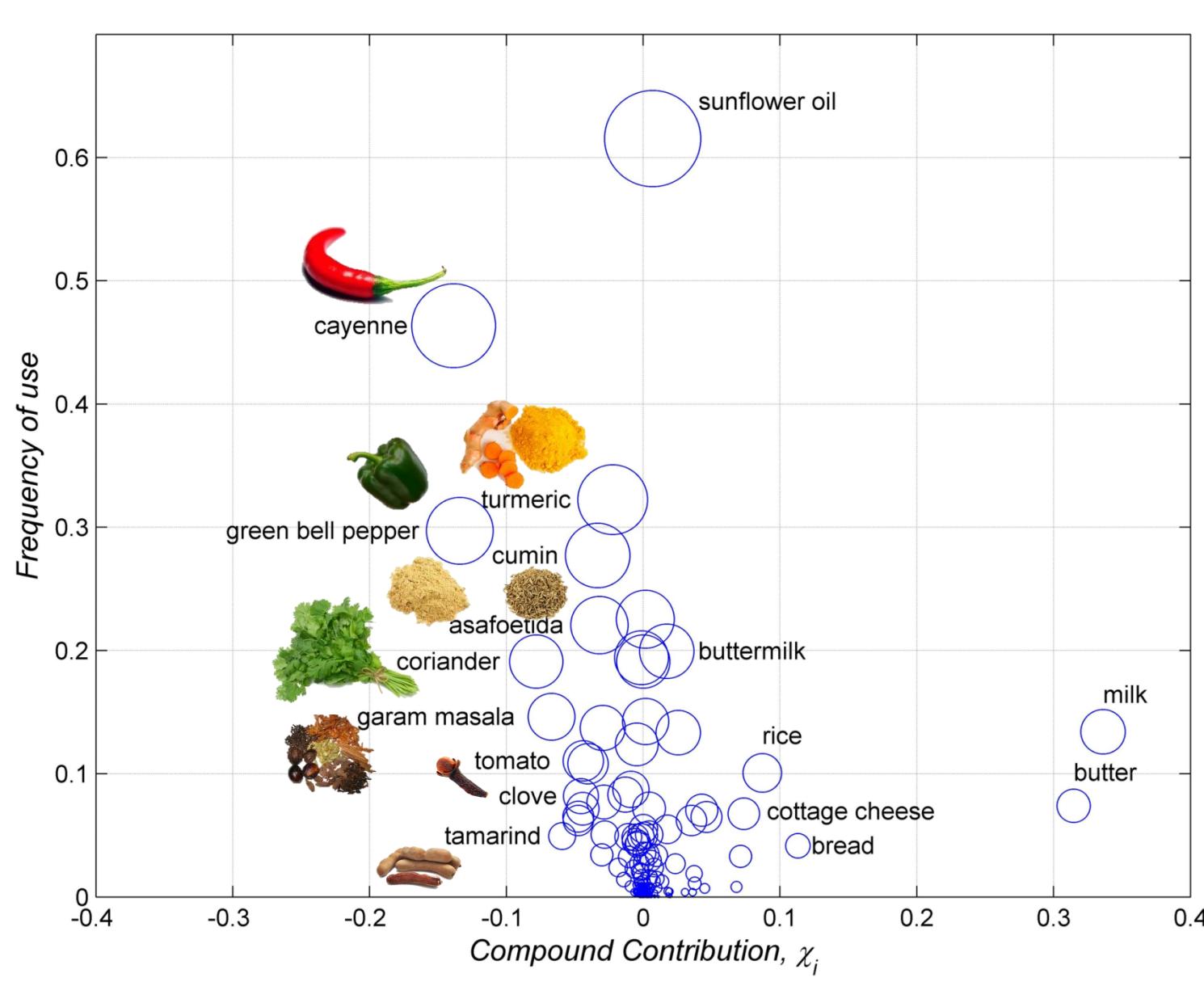


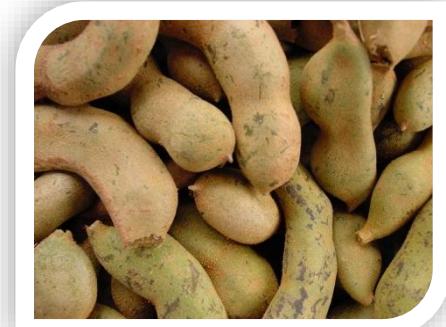
Role of ingredients in biasing the food pairing

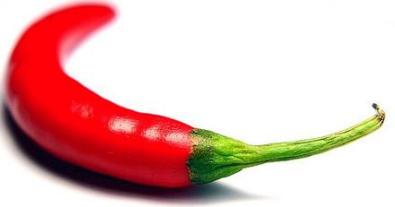
$$+\infty \geq \chi_i \geq -\infty$$

$$\chi_i = \left(\frac{1}{N_R} \sum_{R \ni i} \frac{2}{n(n-1)} \sum_{j \neq i (j \in R)} |F_i \cap F_j| \right) - \left(\frac{2f_i}{N_R \langle n \rangle} \frac{\sum_{j \in c} f_j |F_i \cap F_j|}{\sum_{j \in c} f_j} \right)$$

Role of ingredients in biasing the food pairing







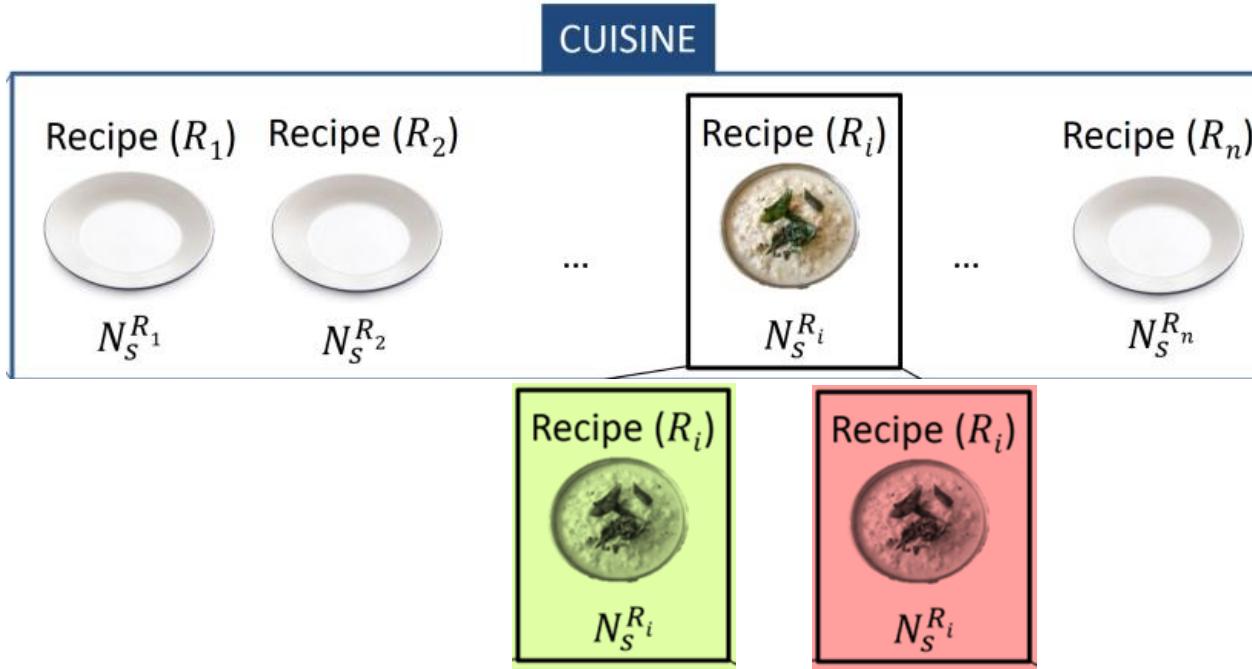
Spice

The Taste of India

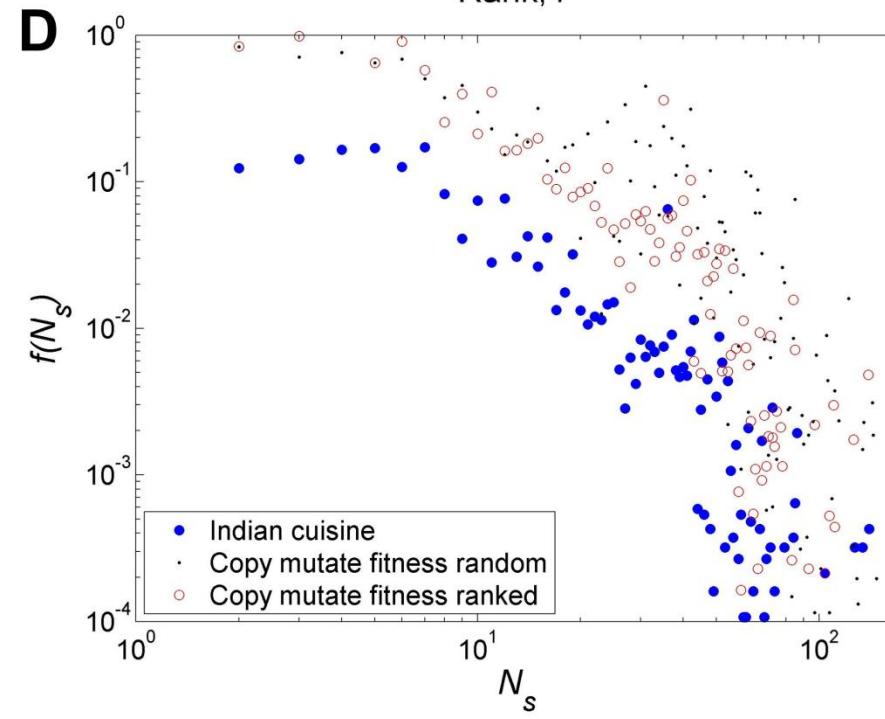
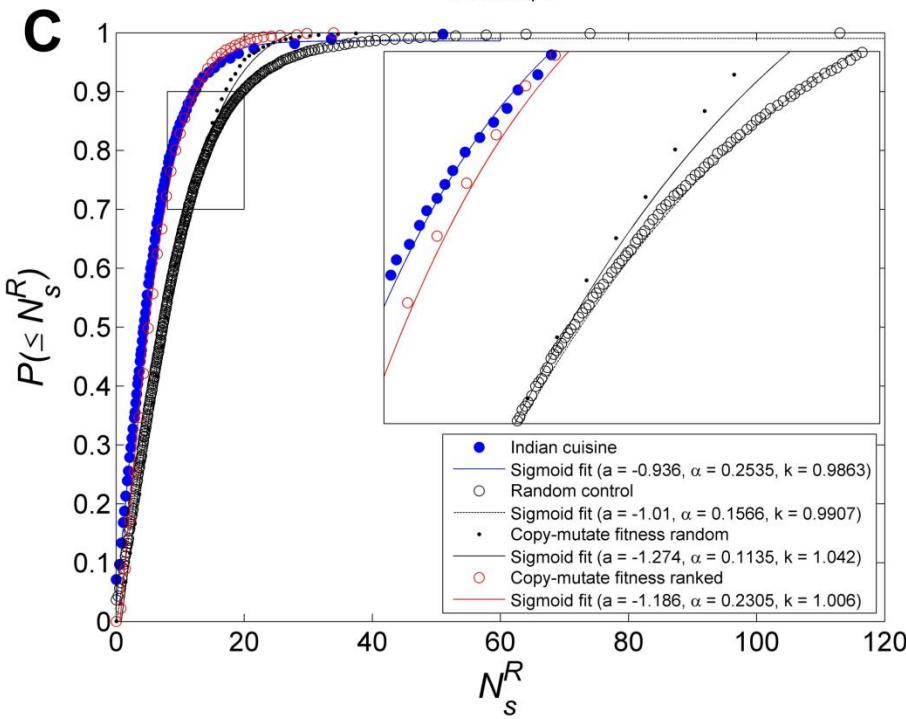
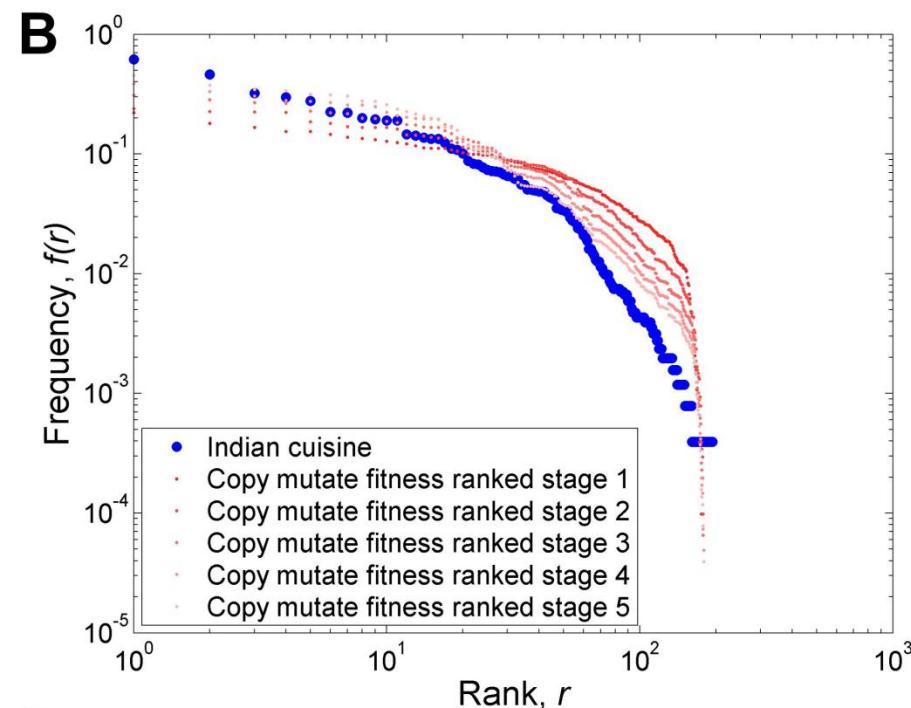
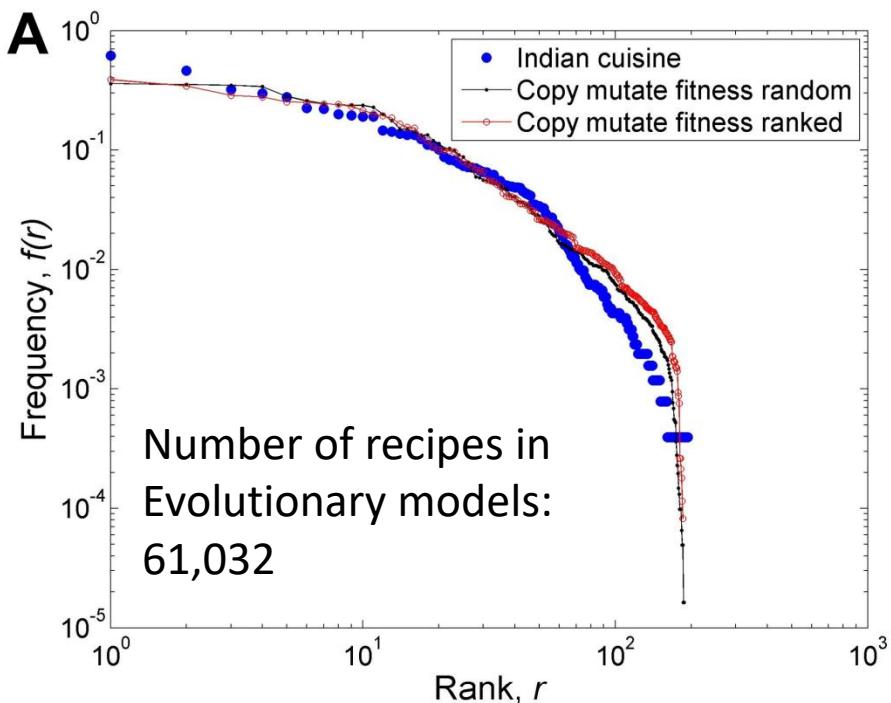
भारत → बहारात



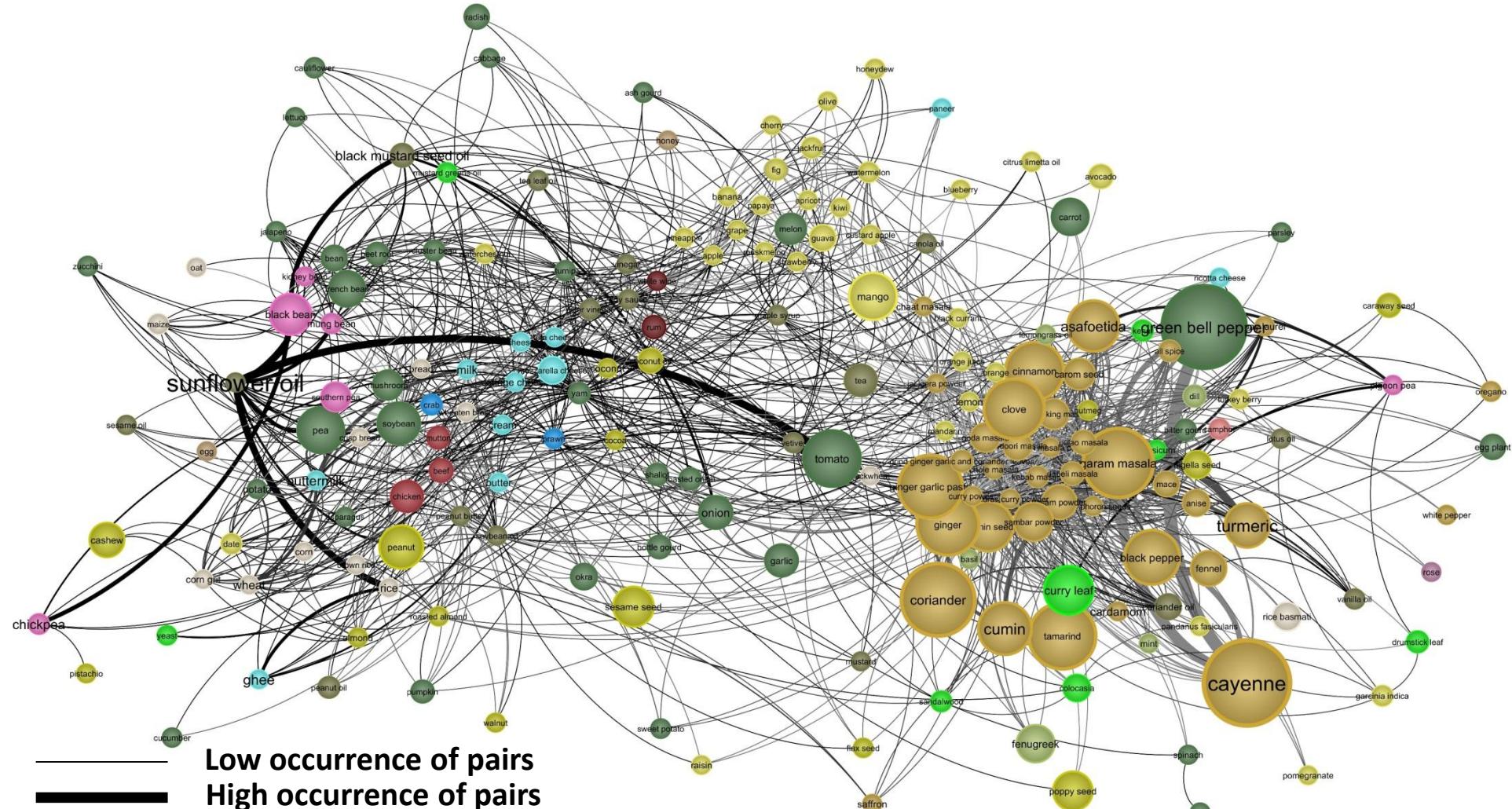
A Culinary Evolution Model



- Ascribe ‘fitness values’ to all the ingredients.
(Model-1: Fitness Random; Model-2: Fitness Scaled)
- Start with a small ‘ingredient pool’
- Create an initial set of recipes ($R_0 = 20$) of size $K (= 7)$ each.
- **Copy** a recipe randomly and **mutate** it $L(=2)$ times.
- Maintain the size ratio of ingredient pool and recipe pool ($M=0.0762$; Indian cuisine).

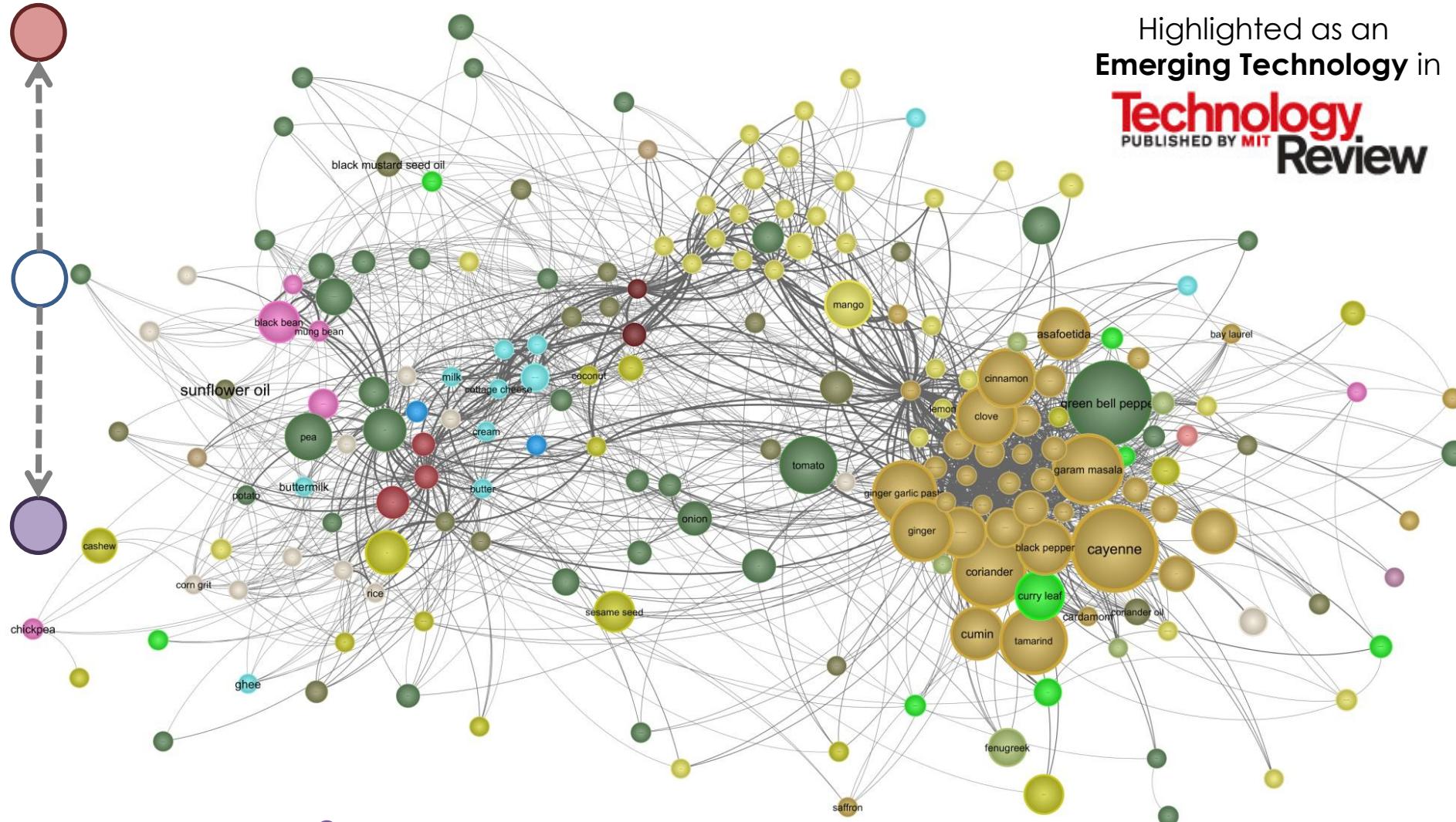


The Flavor Graph based on the Indian Cuisine



Low flavour sharing
Medium flavour sharing
High flavour sharing

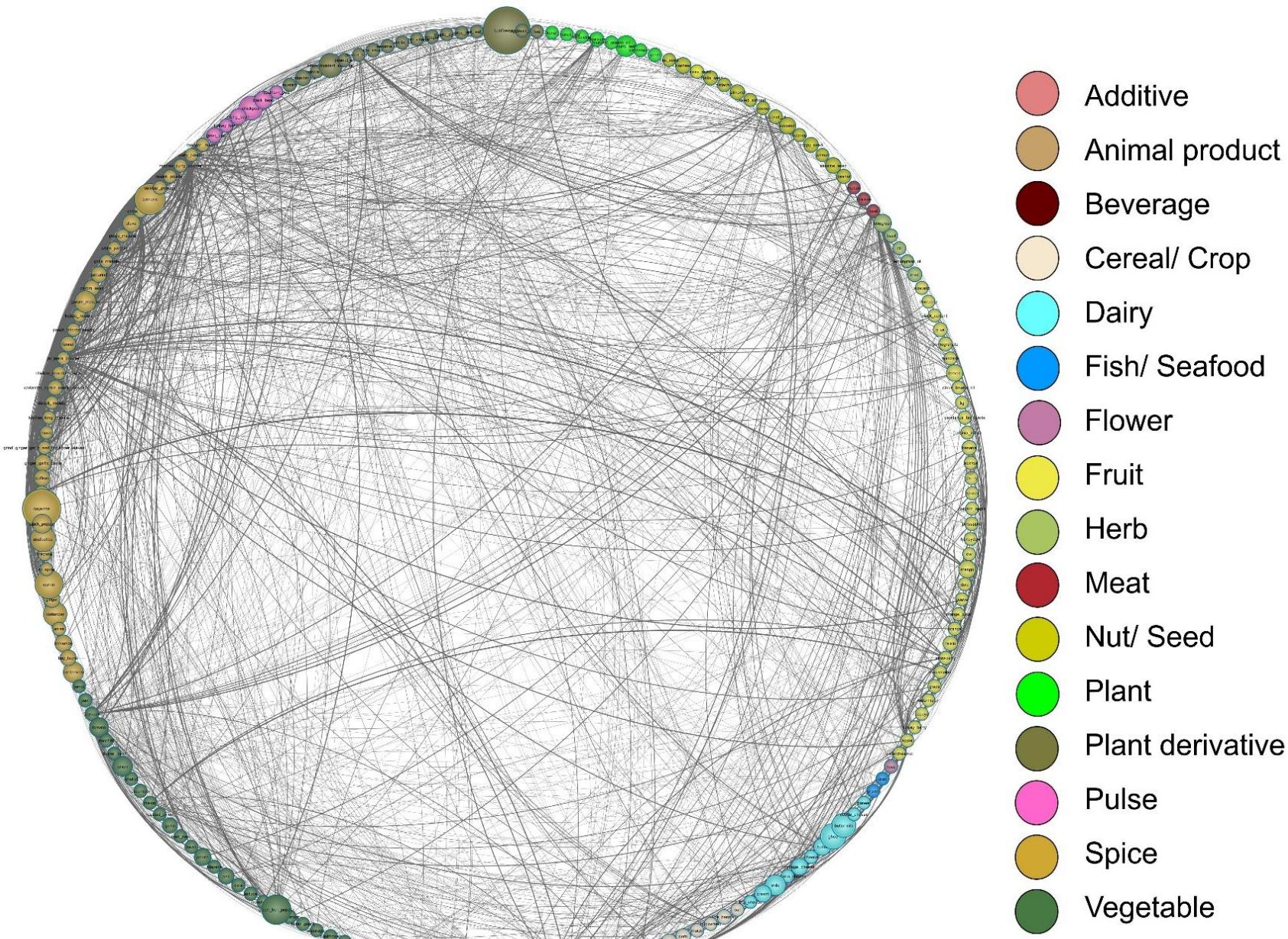
Food-as-Medicine: Molecular landscape of food



Highlighted as an
Emerging Technology in
Technology
PUBLISHED BY MIT **Review**

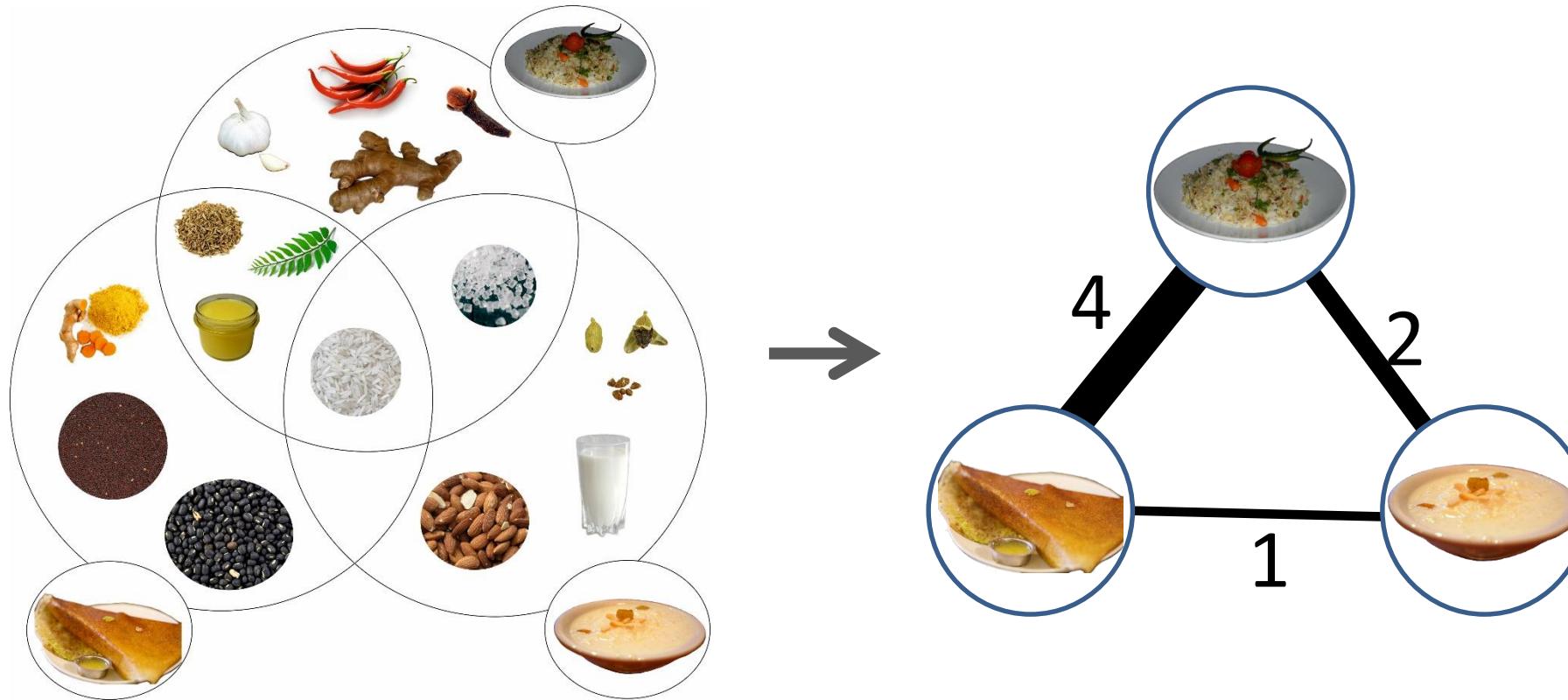
Best of 2015
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The Flavor Graph based on the Indian Cuisine

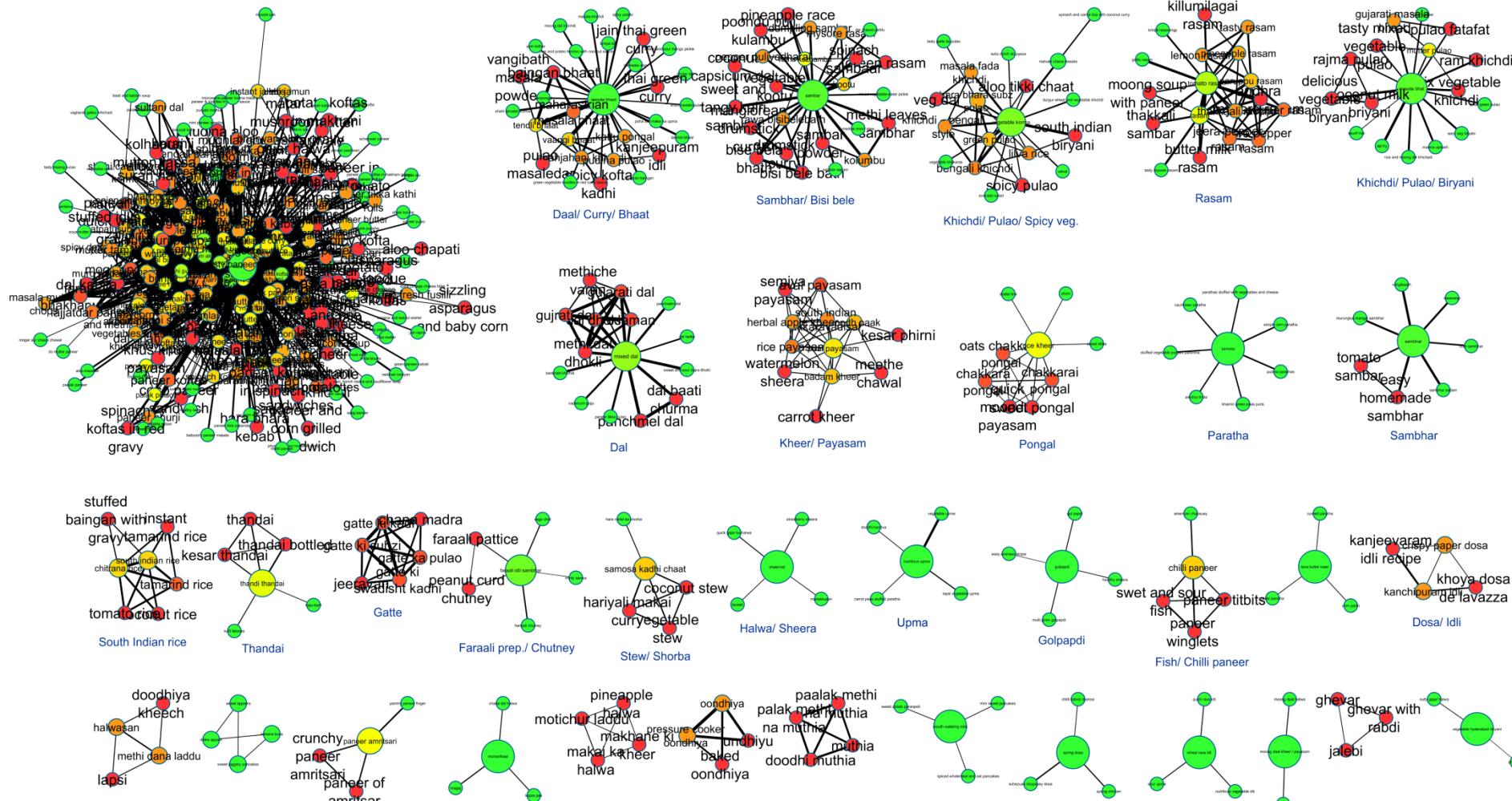


A Jain, NK Rakhi, G Bagler, "Spices form the basis of food pairing in Indian cuisine", arXiv:1502.03815 (2015).

Construction of Recipe Network



Deciphering Recipe Network of Indian Cuisine





The Tribune



DNA

newser

Telegraph



TIME

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not exactly rocket science

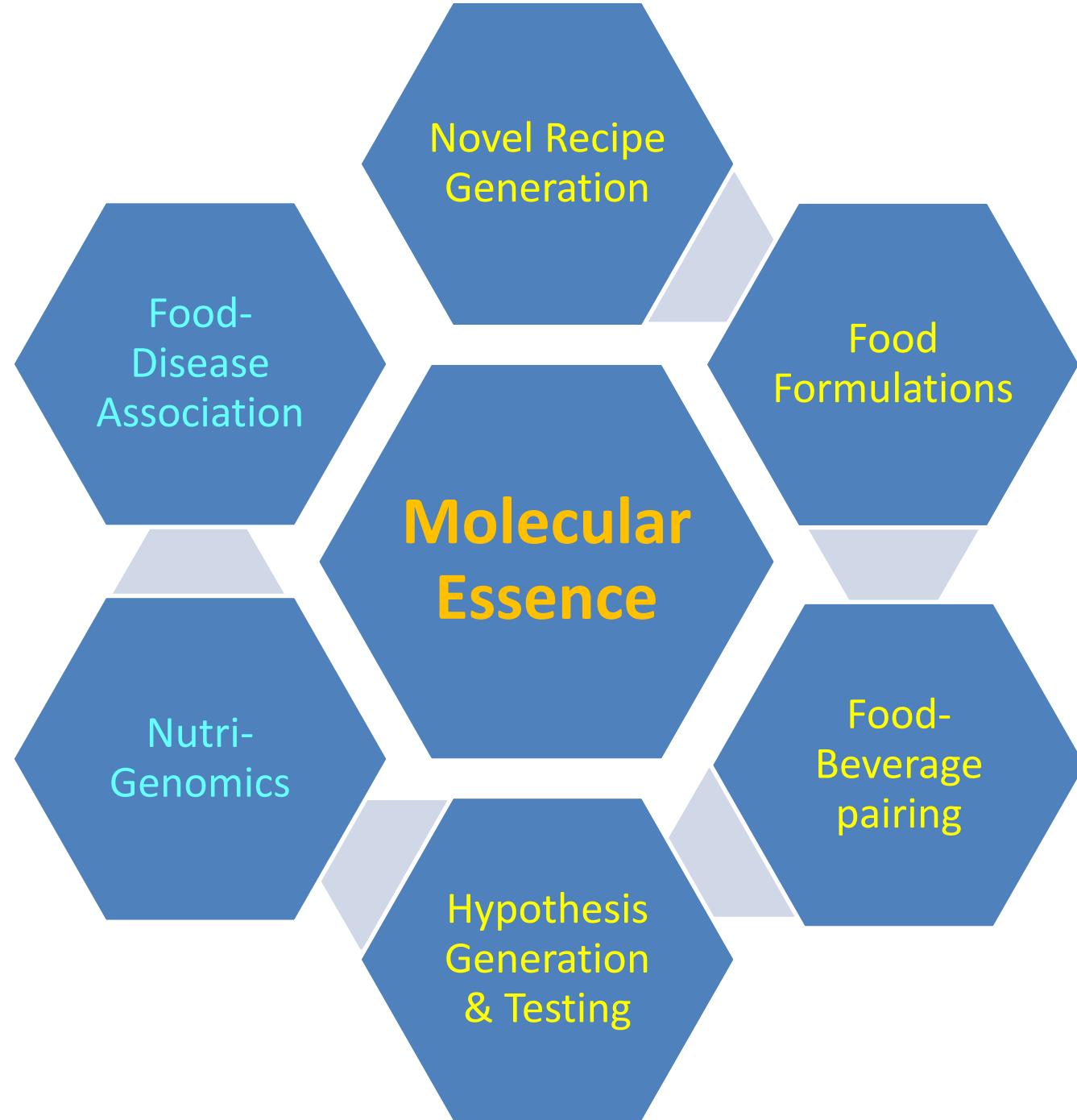
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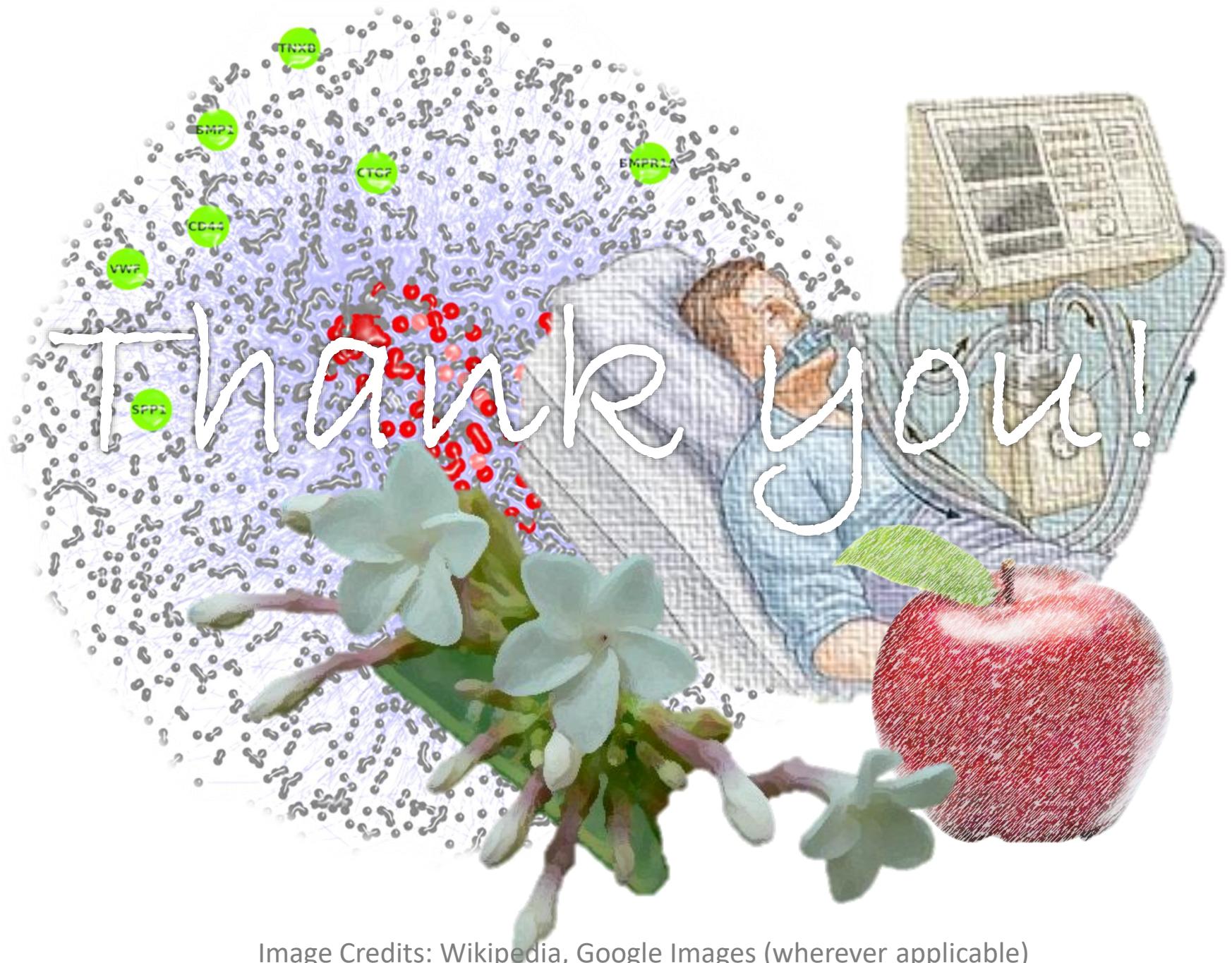


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