

Palatable Computation: Recipe Generation Using Graph Embeddings

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Abstract

Our paper will focus on a tripartite graph connecting flavor compounds to ingredients and ingredients to recipes. On a fundamental level, our analysis will revolve around a graph projection of recipes to ingredients, called the complement network, which is established in previous research done on this data set. In order to improve the complement network, we have created several novel metrics which we will apply to the weighting of the graph. This will allow us to evaluate ingredient relationships in light of a food pairing hypothesis, which asserts the usage of ingredients with similar flavors in Western cuisines and the usage of ingredients with disparate flavors in Eastern cuisines. Furthermore, we create the substitution network defined by Teng et al. without the use of user data and instead inferring which ingredients can be substituted for one another in recipes using our new metrics. Finally, we generate new recipes using the information these two networks provide by starting with a set of seed ingredients or randomly chosen base ingredient and finding suitable additions based on our updated networks and hypotheses.

1. Introduction

The process of recipe development is an intricate, cultural, and creative process which aims to understand and produce palatable dishes with innovative combinations of ingredients. In an attempt to better understand this process, the role of ingredients and flavors in recipes has been questioned and explored. Several hypotheses have been made, only to be contested by contradictory assertions regarding what fundamental combinations create the best recipes. One such hypothesis is the "food pairing hypothesis," which simply asserts that ingredients that share common flavors

combine well in recipes. Graph analysis has recently been used to quantitatively analyze these roles, as it offers an accessible way to process large amounts of data and has inspired new assertions on how recipes are formulated. However, these studies have also brought to light more questions. Do ingredients of similar flavors or disparate flavors combine well in a recipe? Which ingredients can be substituted for one another without altering the underlying taste of a recipe? Can unconventional ingredients be combined to create palatable new creations? This study will strive to answer these types of questions by analyzing the relationships of ingredients, flavors, and recipes, ultimately building upon previous network oriented analyses.

2. Background and Related Work

Previous studies on this topic, using network oriented analysis, have created a foundation for us to explore the data at hand and pose new questions. The following section will briefly analyze three of them, such that we can relate this study to previously observed results.

2.1. Flavor Network [1]

This study gathers data relating ingredients to recipes and flavor compounds to ingredients in order to analyze the general patterns that underlie ingredient and flavor use in modern recipes, across various cultures. As the degree to which a recipe is palatable is largely due to its ingredients, this paper dives deeper into the analysis of ingredients to include the flavor compounds which make up these ingredients, providing a more precise understanding of why recipes use certain combinations of ingredients.

One primary goal of the paper is to evaluate what is called the food pairing hypothesis, which assumes that ingredient pairs with many common flavor compounds go well together in the same dish. This hypothesis

has been a driving force behind the search for novel recipes and ingredient combinations. The authors also hypothesize that, while the food pairing hypothesis is prevalent in Western cuisines, it is much less so in East Asian cuisines.

This paper uses a graph projection of flavors to ingredients, where ingredients are connected when sharing common flavor compounds. These edges are weighted by the number of shared compounds.

In order to characterize each regional cuisine by its flavor compounds, the paper uses an authenticity metric to compare the prevalence of certain ingredients in a specific cuisine to that in all cuisines. This metric showed that the ingredients in East Asian recipes tend to have disparate flavors, while the ingredients in North American and Western European recipes tend to have many flavor compounds in common, confirming their original hypothesis that the proclaimed food pairing hypothesis is only true for a limited set of cuisines.

This paper also performs important preprocessing and evaluation of the data to make for smoother analysis. More specifically, sources of potential error, certain fundamental characteristics of the data, and limitations of the data sets are discussed. One primary example is a concern regarding ingredients that are common in recipes not due to flavor, but due to other roles such as the mechanical stability or the color of the recipe. The authors determine that these confounding factors can be filtered out systematically because of the large size of the data set and will not interfere with the analysis. Ingredients such as egg, flour, or paprika are some examples of ingredients that can perform roles beyond flavor.

2.2. Recipe Recommendation [5]

In this paper, Teng et al. expand on the analysis and use of the food network conducted by Ahn et al. by introducing the bipartite relationship between ingredients and recipes and constructing a graph where an ingredient node and a recipe node have a connecting edge if the recipe uses that ingredient. They then fold the graph to construct an ingredient graph where ingredients are connected based on Pointwise Mutual Information (PMI) defined on pairs of ingredients (a , b):

$$\text{PMI}(a, b) = \log \frac{p(a, b)}{p(a)p(b)}$$

where

$$p(a, b) = \frac{\# \text{ of recipes containing } a \text{ and } b}{\# \text{ of recipes}}$$

$$p(a) = \frac{\# \text{ of recipes containing } a}{\# \text{ of recipes}}$$

$$p(b) = \frac{\# \text{ of recipes containing } b}{\# \text{ of recipes}}$$

This PMI metric tells us how likely two ingredients are to appear together in the same recipe versus separately, where complementary ingredients occur together far more often than would be expected by chance. This graph, which they call the complement network, captures the co-occurrence frequency of two ingredients. They found that this network is composed of two large communities: one savory and one sweet.

Teng et al. also proposed a method for determining a substitution network by scraping user comments suggesting ingredient substitutions from allrecipes.com. This substitution network has edges between two ingredients (a, b) weighted by the $p(a | b)$ for all ingredient pairs (a, b) and represents the ability to switch two ingredients in a recipe without making it any worse.

Ultimately the paper uses its analysis of the food network to show that we can learn interesting insights about the underlying connections between ingredients using the vast data contained in online recipe sharing websites and use these insights to help predict user preferences and recommend recipes.

2.3. food2vec [2]

This article proposes learning embeddings for ingredients and using these embeddings to recommend addition(s) to a given recipe, where the embeddings are learned using word2vec on 100,00 recipes. The concept behind this article is that embeddings enable us to learn the context of ingredients with respect to the rest of the ingredients in the recipe. Then, once these ingredient embeddings are learned, we can use a distance function on the embedding vector space to find the k -closest ingredients to the average of the ingredient embeddings in a given recipe to recommend as additions to said recipe. An example of this is entering in a recipe such as [bread, peanut butter, jelly, honey] and the system recommending strawberry as an additional ingredient.

The paper also found some interesting patterns in the embedding vector space, primarily that cuisines of

a certain locale were clustered together. However, it also found that Northern European and American ingredients had a seemingly random structure, perhaps due to the cultural diversity in these regions or over-representation in the data. Overall, this is an interesting application of modern natural language processing techniques to a recipe dataset in order to quantify the relationships between ingredients.

3. Data

The datasets we will use are sourced from our first reaction paper. Three recipe lists are included from epicurious.com, allrecipes.com, and menupan.com, including 57,691 recipes. In addition, we will use a file connecting ingredients to each flavor compound associated with them, determined by their presence past a certain threshold. There are 1,530 ingredients associated with a total of 1,107 flavor compounds in this file, but only 384 ingredients are included in the recipe data set. As such, only 384 ingredients and 1,107 flavor compounds will be considered.

4. Network Representations of Data

To start, we can improve upon our understanding of recipes which share similar ingredients and on our understanding of ingredients which can be substituted for each other in recipes. These two topics are analyzed by Teng et al., and we plan to expand upon this analysis in several ways.

To do so, we first recreated the original Complement Network from Teng et al.’s paper. Next, we created three networks from our original tripartite graph by connecting flavors to ingredients and ingredients to recipes, which we describe below.

4.1. Food Pairing Hypothesis Network

The first is called the food pairing hypothesis network, which is a modification of the complement network created by Teng et al. Rather than simply folding recipes onto ingredients using the PMI metric to weight the edges, this complement network folds both recipes and flavors onto ingredients, where each node in the network is an ingredient. Edges in this network are weighted by a metric explained below, considering co-occurrence in recipes in addition to shared flavors. We do this so that we can evaluate the findings from Ahn et al.’s paper, where they expand upon the original ”food pairing hypothesis.” To review, they assert that Western cuisines pair ingredients with similar fla-

vors while Eastern cuisines pair ingredients with disparate flavors. The network described in Teng et al.’s paper does not take into account the flavor components of each ingredient; however, we believe that the edge weights in Teng et al.’s complement network should take into account how similar or disparate two ingredients are because of Ahn et al.’s analysis. Thus, we propose a new weighting scheme:

$$\text{RF}(a, b) = \frac{|R_a \cap R_b|}{|R_a \cup R_b|}$$

$$\text{FF}(a, b) = \frac{|F_a \cap F_b|}{|F_a \cup F_b|}$$

$$\text{FPHF}(a, b) = \text{RF}(a, b) * (\text{FF}(a, b) - \text{median}(\text{FF}))^2$$

Here, R_i indicates the set of recipes containing ingredients i , and F_i indicates the set of flavors contained in ingredient i . RF stands for the Recipe Factor, FF for the Flavor Factor, and FPHF for the Food Pairing Hypothesis Factor.

This metric takes into account the analysis done by Ahn et al. because two very similar or very disparate ingredients will have larger edge weights if they also appear in the same recipe. Thus, disparate ingredients should only have large edge weights when actually paired together and small otherwise.

4.2. Updated Complement Network

The second network we create will be another modification to the complement network created by Teng et al.. We propose a new method of weighting the edges in this complement network. In our food pairing hypothesis network, we specifically weight edges between nodes in order to examine the food pairing hypothesis, where differences or similarities in flavors of ingredients will heavily influence the weight of edges. In this updated complement network, we will provide a balance between measuring co-occurrence of ingredients in recipes and their similarity or difference in flavors – co-occurrence of ingredients in recipes plays a greater role in the weighting. We do so with the following metric:

$$\text{COF}(a, b) = \text{PMI}(a, b) + \sqrt{(\text{FF}(a, b) - \text{median}(\text{FF}))^2}$$

Here, we incorporate the PMI metric used in Teng et al.’s original complement network to implement recipe

co-occurrence. We then weight this value by adding the square root of the relative strength of the difference or similarity of flavor profiles. This way, recipe co-occurrence is still the backbone of the network, supplemented by our evaluation of flavor profile.

4.3. Substitution Network

Our third network will be called the substitution network, which will fold both recipes and flavors onto ingredients, but with a separate metric to weight edges in order to evaluate how well ingredients can substitute for one another in a recipe.

While Teng et al.’s paper uses information captured in user reviews and comments to build an ingredient substitution network, we believe that this substitution network can be inferred directly from the food network using the following metric that we propose:

$$SF(a, b) = \frac{FF(a, b)}{1+RF(a, b)}$$

Here, SF stands for the Substitution Factor, which is constructed around the assumption that we can likely substitute one ingredient for another if they do not often appear in the same recipes but have many common flavors. We have constructed the denominator of the substitution factor such that a perfect score is an identical flavor profile with no co-occurrence in recipes. We believe that this weighting metric will produce a network that is similar to the substitution network defined in Teng et al.’s paper. One primary difference is that Teng et al.’s substitution network is directed, whereas our network will be undirected.

4.4. Analysis

The following sections will provide an in-depth analysis of the results of our methods for each network.

4.4.1 Hypothesis

We have identified two types of communities within our graphs:

- Recipe Towns**
- Flavor Towns**

Recipe Towns are communities in our complement network variants, and Flavor Towns are communities

in our substitution network. We hypothesize that Flavor Towns and Recipe Towns will have very little connection or overlap. This is because Recipe Towns should include ingredients that go well together, but Flavor Towns should include ingredients that substitute well for each other and likely could not compose a recipe on their own.

4.4.2 Degree Distributions

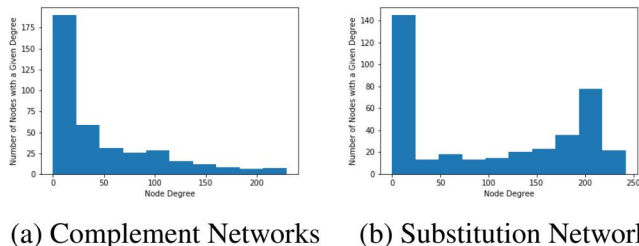


Figure 1: Degree Distributions

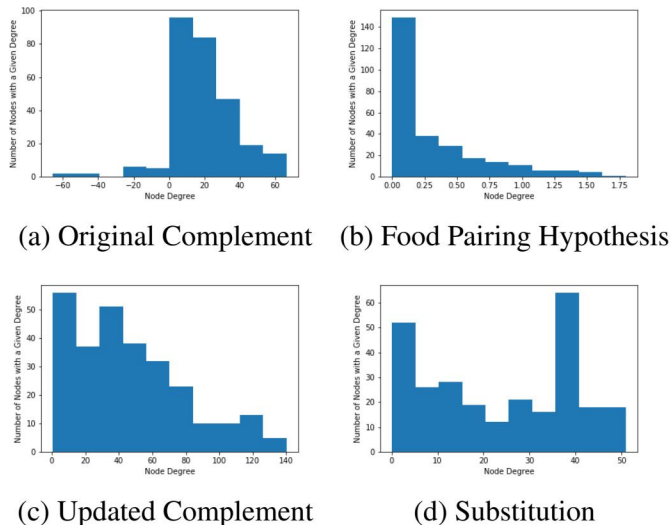


Figure 2: Weighted Degree Distributions

In Figure 2, we compare the weighted degree distributions for each of the networks we have created, in addition to the original complement network. As the unweighted degree distributions will be the same for the original complement network, the food hypothesis network, and the updated complement network, this provides more insight into how our proposed weighting schemes change the structure of the networks.

In the original complement network and the updated complement network, the degree distributions are roughly linear with a negative correlation between

weighted degree and number of nodes. In the updated complement network, we also see a drop-off with higher weighted degrees, which indicates that a small number of ingredients appear in a large number of recipes with many other ingredients.

As the metric used to weight edges in the food pairing hypothesis network compares the number of shared flavors to the median number of shared flavors between ingredients, we can see that many ingredient pairings do not have specifically distinct or similar flavors. Thus, the degree distribution has a roughly logarithmic curve where a high number of ingredients have a small weighted degree and an increasingly small number have a high weighted degree. This contradicts the updated "food pairing hypothesis" made by Ahn et al., as relatively few ingredients used together tend to have specifically similar or disparate flavors. Rather, this supports our hypothesis for recipe generation, which we describe in further detail in section 5.

For our substitution network, the weighted degree distribution shows us that there are many ingredients that are not substitutable for anything and many that are substitutable for a large number of ingredients. Otherwise, this number is relatively consistent across the board.

4.4.3 PageRank

Below are the top 10 PageRank scores for each of our constructed networks:

Ingredient	PageRank	Ingredient	PageRank
butter	0.01428	black tea	0.00623
wheat	0.01327	orange	0.00615
onion	0.01313	roasted beef	0.00589
egg	0.01278	green tea	0.00574
garlic	0.01245	tea	0.00571
vegetable oil	0.01113	jasmine tea	0.00571
black pepper	0.01100	raw beef	0.00564
cream	0.01082	beef	0.00564
olive oil	0.01081	strawberry	0.00553
vinegar	0.01060	soybean	0.00549

(a) Complement Networks

(b) Substitution Network

Table 1: PageRank by Network

In Table 1, we analyze the rankings of pages in each of our networks according to an unweighted PageRank score. This metric provides insight into the most important ingredients, considering how many ingredients they are connected to and how important these ingredients are. The PageRank scores for the original comple-

ment network, the updated complement network, and the food hypothesis network were all the same, as we use the same threshold of number of recipes to qualify an edge to be created. While our food hypothesis network had an additional threshold, this did not affect the results. As such, these are placed in the same category of "complement networks" in Table 1.

In our complement networks, the ingredients with the highest PageRank scores are widely used and serve as base or foundational ingredients in recipes. We see that butter, wheat, and egg are high scoring, which makes sense given that their applications span across different cuisines and varieties of plates, such as appetizers, main dishes, and deserts. The PageRank metric works well in describing the ingredients with the highest scores, but over-inflates ingredients that are used in fewer recipes, as they are likely to be connected to a base ingredient with a high score.

In the substitution network, the PageRank metric shows us which ingredients share more than the average number of flavors in common with many ingredients, but does not necessarily indicate which ingredients are highly substitutable for other ingredients. This is because it is an aggregate metric and doesn't account for weighted edges.

4.4.4 Unconnected Ingredients

Below are randomly sampled ingredient pairs from each of our constructed networks that are unconnected (i.e. do not have an edge between them but may have a path):

Ingredient 1	Ingredient 2	Ingredient 1	Ingredient 2
black pepper	eel	pimento	artichoke
turnip	frankfurter	mandarin	roasted almond
cherry	quince	sheep cheese	cream
huckleberry	beer	litchi	raisin
bartlett pear	date	tequila	mango

(a) Original Complement

(b) Food Pairing Hypothesis

Ingredient 1	Ingredient 2	Ingredient 1	Ingredient 2
orange juice	chickpea	vinegar	shallot
nectarine	lemongrass	rhubarb	feta cheese
wheat bread	sour cherry	palm	walnut
cherry	thai pepper	grapefruit	onion
kumquat	dill	brassica	kumquat

(c) Updated Complement

(d) Substitution

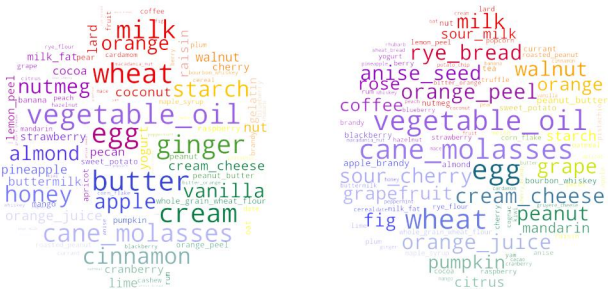
Table 2: Unconnected Ingredients by Network (Random Sample)

By randomly sampling the unconnected ingredient pairs from (a) and (c) in Table 2, we can analyze which ingredients do not pass our threshold for number of shared recipes required to justify an edge. This provides an interesting way to analyze which ingredients are unlikely to appear together in our randomly generated recipes, independent of flavor. As our food pairing hypothesis network also incorporates a threshold requiring either disparate or similar flavors, the requirements are more stringent in order to appear in the same recipes. However, we must note that some disconnected ingredient pairs, such as tequila and mango, may be likely to appear in the same recipe but simply do not hit the recipe threshold. This will not be an issue for recipe generation since there will likely be a path between these two ingredients even if it is not a direct edge.

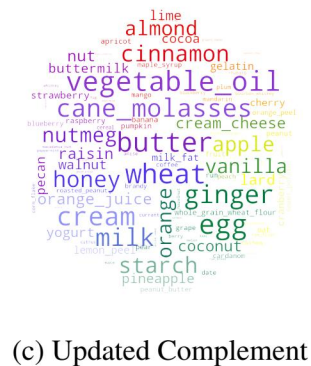
In our substitution network, our threshold for an edge is that the number of flavors in common between two ingredients. As such, the results shown in Table 2 do not meet this requirement and, as expected, appear to share few or no common flavors.

4.4.5 Recipe Towns

Below are the largest Recipe Towns from each of our constructed networks:



(a) Original Complement (b) Food Pairing Hypothesis



(c) Updated Complement

Figure 3: Recipe Towns

By running community detection on each of our networks with the Clauset-Newman-Moore (CNM) algorithm [3] implemented in the SNAP.PY library, we can garner a better understanding of the structure of each network as a whole. In each network, there tends to be one or two Recipe Towns and the rest of the ingredients are in their own communities. This seems to suggest that there are base ingredients and accent ingredients for recipes that make each recipe unique. Without a threshold on the number of recipes required to make an edge, this structure would not be apparent.

In the visualizations shown in Figure 2, the size of each ingredient reflects the degree of that ingredient. As such, we can see that several of the ingredients displayed in larger font, such as egg, butter, and vegetable oil, also have high PageRank scores as shown in Table 1.

4.4.6 Flavor Towns

Below are the two major Flavor Towns extracted from our substitution network:



Figure 4: Flavor Towns

For our substitution network, we also ran the Clauset-Newman-Moore community detection algorithm to find our Flavor Towns. Here, we only found two significant communities, one centered around a variety of cheeses and the other centered around berries and fruits.

This indicates that ingredients with many variations or types are going to have many ingredients possible to be substituted with and will likely have greater weights between them, while other ingredients may have a select few or no ingredients that can be substituted for them.

Furthermore, part (d) from Table 3 in the appendix shows us that various meats are also likely to

have many suitable substitutions, particularly types of seafood.

Finally, we can confirm our hypothesis that our Recipe Towns and Flavor Towns do not resemble one another, as Recipe Towns contain ingredients that appear frequently with one another and Flavor Towns contain similar ingredients which are unlikely to co-occur in recipes.

4.4.7 Ingredient Relationships

See Table 3 in the Appendix for the top ingredients by each metric both overall and for each cuisine.

5. Recipe Generation

Our recipe generation engine is fundamentally an adaption of `node2vec`, where embeddings are created for ingredients and we find similar ingredients using Euclidean distance. The Generation Architecture section will provide a detailed description of the methodology behind the generation engine.

5.1. Hypothesis

While the hypothesis made by Ahn et al. asserts that pairs of ingredients in recipes from Eastern cuisines have significantly fewer shared flavor compounds than random pairs would have, we believe that this hypothesis lacks precision. While key ingredients may specifically have disparate flavors, we hypothesize that there are also ingredients that play the role of fillers, which do not contribute to the prominent flavors in a recipe. As such there must be a reasonable proportion of accent ingredients to base filler ingredients in order to create a palatable recipe. Otherwise, there would simply be an eclectic group of outstanding flavors. We predict that this will be an important factor in generating suitable recipes. As such, we will test recipe generations from each of our networks, expecting to see groupings of overpowering flavors when drawing from our food pairing hypothesis network and more balanced recipes when drawing from the updated complement network. We hypothesize that these expectations will hold regardless of the preset cuisine choice or seed ingredients.

5.2. Generation Architecture

To start, we created our generation engine such that we could generate recipes from any of our networks. Thus, when running `node2vec` to create the pertinent embeddings, we set $p = 1$ and $q = 1$ so that our

weighting metrics would be the driving force in determining the probability that a given node would be reached with a random walk [4].

There are X steps in our generation process:

5.2.1 Seed Ingredients

The generation algorithm enables the user to ask for recipes starting from one of four possibilities:

1. Seed ingredients
2. Cuisine of choice
3. Random cuisine
4. Completely random

Seed ingredients and cuisine choices can be specified explicitly by the user if desired. Otherwise, the user can simply select random cuisine or completely random to test their luck.

If the user does not specify seed ingredients, the generator will randomly select two seed ingredients based on which option 2-4 above is chosen. Once the seed ingredients are selected, the algorithm first determines which embeddings to use based on the user specified network.

5.2.2 Centroid

For each iteration of choosing an ingredient, we calculate the centroid of the current set of ingredient embeddings. Our algorithm uses the centroid rather than the average distance between the embeddings of a new ingredient and each of the embeddings corresponding to ingredients in the current recipe because this is a good approximation and is much faster than the latter option.

The top ingredients with the smallest distance between their embedding and the centroid are then determined.

5.2.3 Choosing New Ingredient

Each time we want to choose a new ingredient, we first rank all of the remaining ingredients based on the euclidean distance between their embeddings and the centroid of this iteration. We then calculate a corresponding proportional probability distribution where the proportional probability of choosing a particular ingredient is the reciprocal of the previously determined distance plus one. We then normalize this prob-

ability distribution by dividing by the sum of all proportional probabilities. We create the probability distribution in this way such that ingredients with smaller distances have a higher probability of being sampled.

5.2.4 Substitution

Another essential component of the generation model and its interface is the option for substituting ingredients. There are two options for doing so.

First, if a user wants to specify allergies or foods they absolutely want to avoid, there is an input option to indicate these foods.

When this option is indicated and one of the specified foods is randomly generated, we first calculate the top ten ingredients with the largest edge weights in the substitution network to the given ingredient. We then calculate the average Euclidean distance between the original complement network embeddings of the potential substitute and those of each ingredient in the rest of the recipe. Finally, we sampled from these top ten ingredients using a probability distribution defined by the weight of the edge minus a fraction of the calculated average distance to the rest of the recipe.

The other option for substituting ingredients is designed to enable evaluation of potential replacements in the recipe due to preference. Once the generation algorithm is run, the user can run a substitution script which, for any specified ingredients and number of potential substitutes, will return the top substitutes according to edge weight in our substitution network. This could also be seen as a manual, rather than automatic, method.

5.2.5 Generation

As stated above, once we have generated the probability distribution among the top ingredients by embedding distance, a random ingredient is then added to the recipe. This process is repeated until the desired length of the recipe is reached.

The generation model also accepts several other arguments: the desired minimum and maximum length of the recipe, which network to use, and the number of accent ingredients desired.

The options for the network used are as follows: original complement network, updated complement network, food pairing hypothesis network, and a combination of the original complement network and the food pairing hypothesis network. In this last option,

base ingredients are chosen via the embeddings from the original complement network and accent ingredients are chosen via the embeddings in the food pairing hypothesis network. This option explores our proposed hypothesis that a palatable recipe must have both base ingredients and accent ingredients.

5.3. Results and Analysis

For the purpose of our analysis, we generated recipes according to each of our three different network generation methods with the same seed ingredient. This enables us to compare the quality of the recipes across different cuisines, as well as compare the recipes generated by the different networks. Of course, a few generated recipes are not truly representative of the algorithm, but they provide enough information for an interesting discussion. Furthermore, as the evaluation of recipes is largely subjective, much of this analysis must be qualitative.

5.3.1 Original Complement Network

Cuisine	Seed	Recipe
American	chicken	lima bean, yam, dill, onion, artichoke, almond
Japanese	chicken	olive oil, caraway, wasabi, sesame oil, roasted sesame seed, enokidake
African	chicken	basil, cardamom, bean, almond, peanut, honey
French	chicken	mushroom, lime juice, vegetable oil, coriander, tamarind, hazelnut

Table 3: Seed Generated Recipes

5.3.2 Food Pairing Hypothesis Network

Cuisine	Seed	Base
American	chicken	celery, tomato juice, cashew, grapefruit, dill, egg
Japanese	chicken	bacon, cauliflower, tabasco pepper, black pepper, nira, cherry
African	chicken	starch, carrot, milk fat, plum, wine, bassica
French	chicken	fenugreek, cottage cheese, cayenne, cashew, carrot, oyster

Table 4: Seed Generated Recipes

5.3.3 Updated Complement Network

Cuisine	Seed	Recipe
American	chicken	kale, coconut, tabasco pepper, champagne wine, cayenne, squash
Japanese	chicken	oyster, cider, milk, cocoa, sesame seed
African	chicken	rose, bell pepper, pea, olive, mustard, mace
French	chicken	beef, basil, lentil, plum, asparagus, bread

Table 5: Seed Generated Recipes

5.3.4 OCN-FPH: Base and Accent

Note that (a) stands for accent ingredient.

Cuisine	Seed	Base	Accent
American	chicken	white wine, oatmeal, cane molasses	beef broth, kale, romano cheese
Japanese	chicken	egg, black bean, lemon	rice, chinese cabbage, sesame seed
African	chicken	lime peel, oil, chick-pea, cane molasses	bell pepper, beet, black pepper
French	chicken	parsley, bone oil, cardamom	seed, brussels sprout, radish

Table 6: Seed Generated Recipes

First, we must note that all three generation networks have the potential to produce high-quality recipes; however, we have noticed through repeated generation that the original complement network and the updated complement network often tend to put multiple meats in the same recipe, whereas the Base and Accent generation method tends not to do this. This leads us to believe that our Base and Accent hypothesis produces better recipes on average, while the original complement network and updated complement network produce pretty good recipes, and the food pairing hypothesis network produces low-quality recipes. As hypothesized the food pairing hypothesis network lacks sufficient base ingredients to consistently create a coherent and balanced recipe.

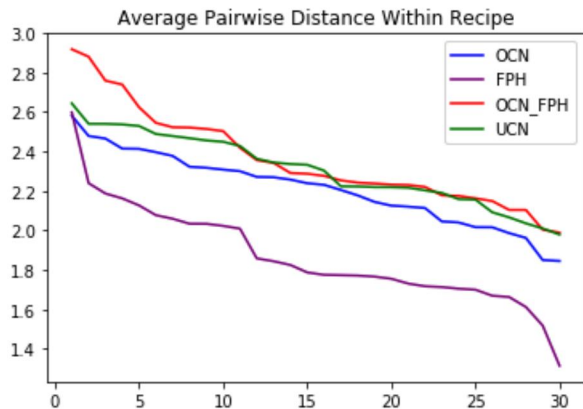


Figure 5

By comparing our results to the trends seen in Figure 5, we can see that it is good to have some distance between ingredients, as the ingredients added through the food pairing hypothesis network are likely to have a further distance from the embeddings from the original complement network. However, the need for base ingredients and some distance between ingredients is clear, as just sampling from the food pairing hypothesis network gives poor results.

6. Conclusion

One remarkable conclusion we gathered was that although recipes created with both the original complement network and the food pairing hypothesis network were consistently of high quality, this was emphasized when the recipe was generated within a certain cuisine rather than completely at random. We believe that the ability to generate good recipes becomes easier when you specify the cuisine since a specific cuisine has been developed and nurtured over the course of hundreds to thousands of years.

Overall, the success of our recipe generation when considering both base and accent ingredients confirms that the updated food pairing hypothesis by Ahn et al. lacks the specification that the foundations of a recipe, regardless of the cuisine, do not rely on specifically similar or disparate flavors.

7. Further Research

One potential focus of further research revolves around the length of recipes. As the relationships between ingredients, particularly the number of base versus accent ingredients, changes with the length of recipes, our generation algorithm could be improved by incorporating a cutoff judging whether superfluous

ingredients have been added to the recipe at hand.

Furthermore, a deeper understanding of the make-ups of base and accent ingredients would also enable for a more precise generation algorithm, as we conclude that this is an essential part of recipe generation.

8. Code

You can find the code for this project at:

<https://github.com/wbakst/food>

References

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- [5] C. Teng, Y. Lin, and L. A. Adamic. Recipe recommendation using ingredient networks. *CoRR*, abs/1111.3919, 2011.

A. Appendix

See following pages for tables.

Ingredient 1	Ingredient 2	Score
lavender	savory	5.672
galanga	thai pepper	5.443
galanga	lemongrass	5.370
bitter orange	brandy	4.913
katsuobushi	seaweed	4.883
whiskey	bourbon whiskey	4.737
kelp	enokidake	4.638
turnip	parsnip	4.422
thai pepper	lemongrass	4.405
wasabi	seaweed	4.400
caraway	rye flour	4.220
sweet potato	yam	4.083
mussel	squid	3.887
sake	katsuobushi	3.792
radish	enokidake	3.767
turmeric	fenugreek	3.761
black mustard seed oil	seed	3.757
caraway	sauerkraut	3.757
lavender	fennel	3.756
shiitake	enokidake	3.739
seed	caraway	3.654
bay	lovage	3.644
clam	mussel	3.637
kelp	sake	3.633
crab	lovage	3.624

(a) PMI

Ingredient 1	Ingredient 2	Score
lavender	savory	6.172
galanga	thai pepper	5.919
galanga	lemongrass	5.870
bitter orange	brandy	5.395
katsuobushi	seaweed	5.383
whiskey	bourbon whiskey	5.211
kelp	enokidake	5.080
turnip	parsnip	4.922
wasabi	seaweed	4.900
thai pepper	lemongrass	4.868
caraway	rye flour	4.720
sweet potato	yam	4.583
mussel	squid	4.358
turmeric	fenugreek	4.261
black mustard seed oil	seed	4.257
caraway	sauerkraut	4.257
shiitake	enokidake	4.222
lavender	fennel	4.220
radish	enokidake	4.219
sake	katsuobushi	4.215
bay	lovage	4.144
crab	lovage	4.091
clam	mussel	4.083
galanga	lime	4.081
kelp	sake	4.081

(c) COF

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.173
egg	wheat	0.124
coriander	fenugreek	0.120
butter	wheat	0.111
turmeric	coriander	0.091
milk	wheat	0.084
garlic	tomato	0.074
garlic	olive oil	0.073
wheat	vanilla	0.073
sesame oil	soy sauce	0.069
lavender	savory	0.066
garlic	cayenne	0.064
black pepper	onion	0.060
cumin	fenugreek	0.059
egg	vegetable oil	0.059
basil	oregano	0.059
onion	pepper	0.059
black pepper	garlic	0.058
ginger	soy sauce	0.057
olive oil	tomato	0.057
cayenne	onion	0.056
egg	vanilla	0.055
chive	cucumber	0.054
fennel	pork sausage	0.054
cumin	coriander	0.053

(b) FPHF

Ingredient 1	Ingredient 2	Score
emmental cheese	munster cheese	1.000
roquefort cheese	munster cheese	1.000
roquefort cheese	emmental cheese	1.000
catfish	haddock	1.000
cheese	emmental cheese	1.000
beef	raw beef	1.000
cod	herring	1.000
mackerel	eel	1.000
cheese	roquefort cheese	0.999
mung bean	bean	0.999
cheese	munster cheese	0.998
jasmine tea	tea	0.994
wine	champagne wine	0.993
goat cheese	sheep cheese	0.992
porcini	enokidake	0.991
mushroom	enokidake	0.989
mung bean	black bean	0.988
mung bean	kidney bean	0.988
red bean	bean	0.988
red bean	mung bean	0.988
red wine	cabernet sauvignon wine	0.988
eel	fish	0.984
fish	haddock	0.984
herring	fish	0.984
jamaican rum	rum	0.983

(d) SF

Table 7: Top 25 Ingredients For Each Metric

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
sweet_potato	yam	4.584
turmeric	fenugreek	4.261
seed	caraway	4.063
coriander	fenugreek	3.994
sage	marjoram	3.824

(b) COF

Ingredient 1	Ingredient 2	Score
fish	haddock	0.984
tuna	salmon	0.983
bacon	pork_sausage	0.972
cod	fish	0.970
cheese	feta_cheese	0.965

(c) SN

Ingredient 1	Ingredient 2	Score
sweet_potato	yam	4.084
turmeric	fenugreek	3.761
seed	caraway	3.654
coriander	fenugreek	3.526
sage	marjoram	3.424

(d) PMI

Table 8: Top 5 For Cuisine: african

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
lavender	savory	6.173
galanga	thai_pepper	5.919
galanga	lemongrass	5.871
bitter_orange	brandy	5.396
katsuoibushi	seaweed	5.383

(b) COF

Ingredient 1	Ingredient 2	Score
roquefort_cheese	munster_cheese	1.000
catfish	haddock	1.000
cod	herring	1.000
cheese	roquefort_cheese	1.000
mung_bean	bean	1.000

(c) SN

Ingredient 1	Ingredient 2	Score
lavender	savory	5.673
galanga	thai_pepper	5.443
galanga	lemongrass	5.371
bitter_orange	brandy	4.913
katsuoibushi	seaweed	4.883

(d) PMI

Table 9: Top 5 For Cuisine: american

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
galanga	thai_pepper	5.919
galanga	lemongrass	5.871
bitter_orange	brandy	5.396
katsuoibushi	seaweed	5.383
turnip	parsnip	4.922

(b) COF

Ingredient 1	Ingredient 2	Score
mung_bean	bean	1.000
jasmine_tea	tea	0.994
wine	champagne_wine	0.994
mung_bean	black_bean	0.989
tuna	salmon	0.983

(c) SN

Ingredient 1	Ingredient 2	Score
galanga	thai_pepper	5.443
galanga	lemongrass	5.371
bitter_orange	brandy	4.913
katsuoibushi	seaweed	4.883
turnip	parsnip	4.422

(d) PMI

Table 10: Top 5 For Cuisine: asian

Ingredient 1	Ingredient 2	Score
egg	wheat	0.125
butter	wheat	0.111
milk	wheat	0.085
wheat	vanilla	0.074
black_pepper	onion	0.060

(a) FPHF

Ingredient 1	Ingredient 2	Score
plum	apricot	2.734
white_bread	marjoram	2.440
celery	marjoram	2.438
bay	veal	2.421
brandy	apricot	2.387

(b) COF

Ingredient 1	Ingredient 2	Score
black_pepper	pepper	0.903
bread	white_bread	0.855
tea	black_tea	0.669
lemon	orange	0.477
hazelnut	walnut	0.469

(c) SN

Ingredient 1	Ingredient 2	Score
plum	apricot	2.543
celery	marjoram	2.094
white_bread	marjoram	1.994
bay	veal	1.921
brandy	apricot	1.902

(d) PMI

Table 11: Top 5 For Cuisine: austria

Ingredient 1	Ingredient 2	Score
turmeric	coriander	0.091
garlic	tomato	0.075
garlic	cayenne	0.064
black_pepper	onion	0.060
black_pepper	garlic	0.059

(a) FPHF

Ingredient 1	Ingredient 2	Score
turmeric	coriander	3.715
cumin	coriander	3.009
cumin	turmeric	2.810
cumin	cilantro	2.233
turmeric	cardamom	2.149

(b) COF

Ingredient 1	Ingredient 2	Score
black_pepper	cayenne	0.762
rice	salmon	0.314
beef	salmon	0.292
ginger	cardamom	0.271
shrimp	salmon	0.267

(c) SN

Ingredient 1	Ingredient 2	Score
turmeric	coriander	3.303
cumin	turmeric	2.678
cumin	coriander	2.623
turmeric	cardamom	1.756
cumin	cilantro	1.733

(d) PMI

Table 12: Top 5 For Cuisine: bangladesh

Ingredient 1	Ingredient 2	Score
egg	wheat	0.125
butter	wheat	0.111
milk	wheat	0.085
wheat	vanilla	0.074
black_pepper	onion	0.060

(a) FPHF

Ingredient 1	Ingredient 2	Score
mussel	white_wine	2.873
bay	thyme	2.401
bay	leek	2.294
raisin	citrus	2.266
leek	thyme	2.114

(b) COF

Ingredient 1	Ingredient 2	Score
cheese	parmesan_cheese	0.657
lemon	citrus	0.647
bacon	chicken	0.513
bacon	beef	0.454
beef	chicken	0.430

(c) SN

Ingredient 1	Ingredient 2	Score
mussel	white_wine	2.435
bay	thyme	1.901
raisin	citrus	1.824
cinnamon	nutmeg	1.797
bay	leek	1.794

(d) PMI

Table 13: Top 5 For Cuisine: belgium

Ingredient 1	Ingredient 2	Score
egg	wheat	0.125
butter	wheat	0.111
milk	wheat	0.085
garlic	tomato	0.075
garlic	olive_oil	0.074

(a) FPHF

Ingredient 1	Ingredient 2	Score
sweet_potato	yam	4.584
bay	lovage	4.145
crab	lovage	4.092
clam	mussel	4.084
sage	marjoram	3.824

(b) COF

Ingredient 1	Ingredient 2	Score
catfish	fish	0.982
mushroom	porcini	0.978
red_kidney_bean	lima_bean	0.975
bacon	pork_sausage	0.972
shiitake	porcini	0.957

(c) SN

Ingredient 1	Ingredient 2	Score
sweet_potato	yam	4.084
bay	lovage	3.645
clam	mussel	3.638
crab	lovage	3.625
sage	marjoram	3.424

(d) PMI

Table 14: Top 5 For Cuisine: cajun creole

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
lavender	savory	6.173
bitter_orange	brandy	5.396
turnip	parsnip	4.922
caraway	rye_flour	4.720
sweet_potato	yam	4.584

(b) COF

Ingredient 1	Ingredient 2	Score
fish	haddock	0.984
tuna	salmon	0.983
cottage_cheese	cream_cheese	0.980
salmon	smoked_salmon	0.979
mushroom	porcini	0.978

(c) SN

Ingredient 1	Ingredient 2	Score
lavender	savory	5.673
bitter_orange	brandy	4.913
turnip	parsnip	4.422
caraway	rye_flour	4.220
sweet_potato	yam	4.084

(d) PMI

Table 15: Top 5 For Cuisine: canada

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
bitter_orange	brandy	5.396
turmeric	fenugreek	4.261
bay	lovage	4.145
crab	lovage	4.092
coriander	fenugreek	3.994

(b) COF

Ingredient 1	Ingredient 2	Score
bacon	pork_sausage	0.972
cod	fish	0.970
pork	roasted_pork	0.966
bean	black_bean	0.960
cheese	cream_cheese	0.948

(c) SN

Ingredient 1	Ingredient 2	Score
bitter_orange	brandy	4.913
turmeric	fenugreek	3.761
bay	lovage	3.645
crab	lovage	3.625
coriander	fenugreek	3.526

(d) PMI

Table 16: Top 5 For Cuisine: caribbean

Ingredient 1	Ingredient 2	Score
egg	wheat	0.125
butter	wheat	0.111
turmeric	coriander	0.091
milk	wheat	0.085
garlic	tomato	0.075

(a) FPHF

Ingredient 1	Ingredient 2	Score
bitter_orange	brandy	5.396
clam	mussel	4.084
lime_juice	lime_peel_oil	3.823
turmeric	coriander	3.715
tequila	lime	3.524

(b) COF

Ingredient 1	Ingredient 2	Score
wine	champagne_wine	0.994
tuna	salmon	0.983
cottage_cheese	cream_cheese	0.980
bacon	pork_sausage	0.972
cod	fish	0.970

(c) SN

Ingredient 1	Ingredient 2	Score
bitter_orange	brandy	4.913
clam	mussel	3.638
lime_juice	lime_peel_oil	3.400
turmeric	coriander	3.303
bitter_orange	orange	3.036

(d) PMI

Table 17: Top 5 For Cuisine: central southamerican

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
bitter_orange	brandy	5.396
kelp	enokidake	5.081
mussel	squid	4.358
turmeric	fenugreek	4.261
shiitake	enokidake	4.223

(b) COF

Ingredient 1	Ingredient 2	Score
mackerel	eel	1.000
wine	champagne_wine	0.994
mushroom	enokidake	0.990
eel	fish	0.985
tuna	salmon	0.983

(c) SN

Ingredient 1	Ingredient 2	Score
bitter_orange	brandy	4.913
kelp	enokidake	4.638
mussel	squid	3.887
sake	katsuobushi	3.793
radish	enokidake	3.768

(d) PMI

Table 18: Top 5 For Cuisine: chinese

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	4.261
coriander	fenugreek	3.994
turmeric	coriander	3.715
cumin	fenugreek	3.304
cumin	coriander	3.009

(b) COF

Ingredient 1	Ingredient 2	Score
black_pepper	pepper	0.903
cayenne	pepper	0.828
black_pepper	cayenne	0.762
bread	wheat_bread	0.566
beef	chicken	0.430

(c) SN

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	3.761
coriander	fenugreek	3.526
turmeric	coriander	3.303
cumin	fenugreek	2.840
cumin	turmeric	2.678

(d) PMI

Table 19: Top 5 For Cuisine: east-african

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
katsuobushi	seaweed	5.383
kelp	enokidake	5.081
wasabi	seaweed	4.901
mussel	squid	4.358
turmeric	fenugreek	4.261

(b) COF

Ingredient 1	Ingredient 2	Score
beef	raw_beef	1.000
mackerel	eel	1.000
mung_bean	bean	1.000
mushroom	enokidake	0.990
mung_bean	black_bean	0.989

(c) SN

Ingredient 1	Ingredient 2	Score
katsuobushi	seaweed	4.883
kelp	enokidake	4.638
wasabi	seaweed	4.401
mussel	squid	3.887
sake	katsuobushi	3.793

(d) PMI

Table 20: Top 5 For Cuisine: east asian

Ingredient 1	Ingredient 2	Score
egg	wheat	0.125
butter	wheat	0.111
milk	wheat	0.085
garlic	tomato	0.075
garlic	olive_oil	0.074

(a) FPHF

Ingredient 1	Ingredient 2	Score
caraway	rye_flour	4.720
caraway	sauerkraut	4.257
seed	caraway	4.063
sage	marjoram	3.824
savory	fennel	3.555

(b) COF

Ingredient 1	Ingredient 2	Score
cottage_cheese	cream_cheese	0.980
bacon	pork_sausage	0.972
cod	fish	0.970
pork	roasted_pork	0.966
cottage_cheese	cheese	0.957

(c) SN

Ingredient 1	Ingredient 2	Score
caraway	rye_flour	4.220
caraway	sauerkraut	3.757
seed	caraway	3.654
sage	marjoram	3.424
savory	fennel	3.055

(d) PMI

Table 21: Top 5 For Cuisine: eastern-europe

Ingredient 1	Ingredient 2	Score
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
milk	wheat	0.085
garlic	tomato	0.075

(a) FPHF

Ingredient 1	Ingredient 2	Score
turnip	parsnip	4.922
caraway	rye_flour	4.720
caraway	sauerkraut	4.257
bay	lovage	4.145
seed	caraway	4.063

(b) COF

Ingredient 1	Ingredient 2	Score
wine	champagne_wine	0.994
fish	haddock	0.984
cottage_cheese	cream_cheese	0.980
salmon	smoked_salmon	0.979
mushroom	porcini	0.978

(c) SN

Ingredient 1	Ingredient 2	Score
turnip	parsnip	4.422
caraway	rye_flour	4.220
caraway	sauerkraut	3.757
seed	caraway	3.654
bay	lovage	3.645

(d) PMI

Table 22: Top 5 For Cuisine: easterneuropean russian

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
bitter_orange	brandy	5.396
turnip	parsnip	4.922
caraway	rye_flour	4.720
turmeric	fenugreek	4.261
clam	mussel	4.084

(b) COF

Ingredient 1	Ingredient 2	Score
wine	champagne_wine	0.994
bacon	pork_sausage	0.972
pork	roasted_pork	0.966
goat_cheese	cheese	0.961
goat_cheese	romano_cheese	0.954

(c) SN

Ingredient 1	Ingredient 2	Score
bitter_orange	brandy	4.913
turnip	parsnip	4.422
caraway	rye_flour	4.220
turmeric	fenugreek	3.761
seed	caraway	3.654

(d) PMI

Table 23: Top 5 For Cuisine: english scottish

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
lavender	savory	6.173
bitter_orange	brandy	5.396
turnip	parsnip	4.922
mussel	squid	4.358
turmeric	fenugreek	4.261

(b) COF

Ingredient 1	Ingredient 2	Score
roquefort_cheese	munster_cheese	1.000
cheese	roquefort_cheese	1.000
cheese	munster_cheese	0.998
wine	champagne_wine	0.994
goat_cheese	sheep_cheese	0.992

(c) SN

Ingredient 1	Ingredient 2	Score
lavender	savory	5.673
bitter_orange	brandy	4.913
turnip	parsnip	4.422
mussel	squid	3.887
turmeric	fenugreek	3.761

(d) PMI

Table 24: Top 5 For Cuisine: french

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
caraway	rye_flour	4.720
turmeric	fenugreek	4.261
caraway	sauerkraut	4.257
seed	caraway	4.063
coriander	fenugreek	3.994

(b) COF

Ingredient 1	Ingredient 2	Score
cottage_cheese	cream_cheese	0.980
frankfurter	veal	0.980
bacon	pork_sausage	0.972
pork	roasted_pork	0.966
cottage_cheese	cheese	0.957

(c) SN

Ingredient 1	Ingredient 2	Score
caraway	rye_flour	4.220
turmeric	fenugreek	3.761
caraway	sauerkraut	3.757
seed	caraway	3.654
coriander	fenugreek	3.526

(d) PMI

Table 25: Top 5 For Cuisine: german

Ingredient 1	Ingredient 2	Score
egg	wheat	0.125
butter	wheat	0.111
milk	wheat	0.085
garlic	tomato	0.075
garlic	olive_oil	0.074

(a) FPHF

Ingredient 1	Ingredient 2	Score
mussel	squid	4.358
clam	mussel	4.084
sage	marjoram	3.824
savory	fennel	3.555
clam	squid	3.523

(b) COF

Ingredient 1	Ingredient 2	Score
cottage_cheese	cream_cheese	0.980
tuna	smoked_salmon	0.977
cheese	feta_cheese	0.965
goat_cheese	cheese	0.961
cottage_cheese	cheese	0.957

(c) SN

Ingredient 1	Ingredient 2	Score
mussel	squid	3.887
clam	mussel	3.638
sage	marjoram	3.424
clam	squid	3.217
savory	fennel	3.055

(d) PMI

Table 26: Top 5 For Cuisine: greek

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
galanga	thai_pepper	5.919
galanga	lemongrass	5.871
bitter_orange	brandy	5.396
turnip	parsnip	4.922
thai_pepper	lemongrass	4.869

(b) COF

Ingredient 1	Ingredient 2	Score
mung_bean	bean	1.000
mung_bean	kidney_bean	0.989
fish	haddock	0.984
mushroom	porcini	0.978
cod	fish	0.970

(c) SN

Ingredient 1	Ingredient 2	Score
galanga	thai_pepper	5.443
galanga	lemongrass	5.371
bitter_orange	brandy	4.913
turnip	parsnip	4.422
thai_pepper	lemongrass	4.406

(d) PMI

Table 27: Top 5 For Cuisine: indian

Ingredient 1	Ingredient 2	Score
egg	wheat	0.125
butter	wheat	0.111
turmeric	coriander	0.091
milk	wheat	0.085
garlic	tomato	0.075

(a) FPHF

Ingredient 1	Ingredient 2	Score
galanga	lime	4.081
turmeric	coriander	3.715
galanga	coriander	3.698
galanga	coconut	3.550
chive	cucumber	3.072

(b) COF

Ingredient 1	Ingredient 2	Score
black_pepper	pepper	0.903
cayenne	pepper	0.828
black_pepper	cayenne	0.762
peanut_butter	peanut	0.610
pork	chicken	0.501

(c) SN

Ingredient 1	Ingredient 2	Score
galanga	lime	3.581
turmeric	coriander	3.303
galanga	coriander	3.216
galanga	coconut	3.050
peanut_butter	peanut	2.701

(d) PMI

Table 28: Top 5 For Cuisine: indonesia

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	4.261
coriander	fenugreek	3.994
turmeric	coriander	3.715
cumin	fenugreek	3.304
cumin	coriander	3.009

(b) COF

Ingredient 1	Ingredient 2	Score
black_pepper	pepper	0.903
cayenne	pepper	0.828
black_pepper	cayenne	0.762
meat	lamb	0.650
lemon	lime	0.645

(c) SN

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	3.761
coriander	fenugreek	3.526
turmeric	coriander	3.303
cumin	fenugreek	2.840
cumin	turmeric	2.678

(d) PMI

Table 29: Top 5 For Cuisine: iran

Ingredient 1	Ingredient 2	Score
egg	wheat	0.125
butter	wheat	0.111
milk	wheat	0.085
garlic	tomato	0.075
garlic	olive_oil	0.074

(a) FPHF

Ingredient 1	Ingredient 2	Score
turnip	parsnip	4.922
seed	caraway	4.063
sage	marjoram	3.824
fennel	pork_sausage	3.446
berry	cranberry	3.358

(b) COF

Ingredient 1	Ingredient 2	Score
salmon	smoked_salmon	0.979
mushroom	porcini	0.978
bacon	pork_sausage	0.972
pork	roasted_pork	0.966
cheese	feta_cheese	0.965

(c) SN

Ingredient 1	Ingredient 2	Score
turnip	parsnip	4.422
seed	caraway	3.654
sage	marjoram	3.424
berry	cranberry	3.348
blackberry	raspberry	3.111

(d) PMI

Table 30: Top 5 For Cuisine: irish

Ingredient 1	Ingredient 2	Score
egg	wheat	0.125
butter	wheat	0.111
turmeric	coriander	0.091
milk	wheat	0.085
garlic	olive_oil	0.074

(a) FPHF

Ingredient 1	Ingredient 2	Score
turmeric	coriander	3.715
cumin	coriander	3.009
cumin	turmeric	2.810
mint	lamb	2.789
roasted_sesame_seed	chickpea	2.778

(b) COF

Ingredient 1	Ingredient 2	Score
roasted_sesame_seed	sesame_seed	0.772
black_pepper	cayenne	0.762
turkey	lamb	0.730
nut	walnut	0.527
pecan	turkey	0.419

(c) SN

Ingredient 1	Ingredient 2	Score
turmeric	coriander	3.303
cumin	turmeric	2.678
cumin	coriander	2.623
mint	lamb	2.346
roasted_sesame_seed	chickpea	2.278

(d) PMI

Table 31: Top 5 For Cuisine: israel

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
lavender	savory	6.173
bitter_orange	brandy	5.396
whiskey	bourbon_whiskey	5.211
turnip	parsnip	4.922
caraway	rye_flour	4.720

(b) COF

Ingredient 1	Ingredient 2	Score
catfish	haddock	1.000
cheese	roquefort_cheese	1.000
wine	champagne_wine	0.994
goat_cheese	sheep_cheese	0.992
red_wine	cabernet_sauvignon_wine	0.988

(c) SN

Ingredient 1	Ingredient 2	Score
lavender	savory	5.673
bitter_orange	brandy	4.913
whiskey	bourbon_whiskey	4.738
turnip	parsnip	4.422
caraway	rye_flour	4.220

(d) PMI

Table 32: Top 5 For Cuisine: italian

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
katsuoibushi	seaweed	5.383
kelp	enokidake	5.081
wasabi	seaweed	4.901
turmeric	fenugreek	4.261
shiitake	enokidake	4.223

(b) COF

Ingredient 1	Ingredient 2	Score
mackerel	eel	1.000
mushroom	enokidake	0.990
red_bean	bean	0.989
eel	fish	0.985
tuna	salmon	0.983

(c) SN

Ingredient 1	Ingredient 2	Score
katsuoibushi	seaweed	4.883
kelp	enokidake	4.638
wasabi	seaweed	4.401
sake	katsuoibushi	3.793
radish	enokidake	3.768

(d) PMI

Table 33: Top 5 For Cuisine: japanese

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
turnip	parsnip	4.922
caraway	rye_flour	4.720
sweet_potato	yam	4.584
turmeric	fenugreek	4.261
seed	caraway	4.063

(b) COF

Ingredient 1	Ingredient 2	Score
red_wine	cabernet_sauvignon_wine	0.988
cottage_cheese	cream_cheese	0.980
salmon	smoked_salmon	0.979
mushroom	porcini	0.978
cod	fish	0.970

(c) SN

Ingredient 1	Ingredient 2	Score
turnip	parsnip	4.422
caraway	rye_flour	4.220
sweet_potato	yam	4.084
turmeric	fenugreek	3.761
seed	caraway	3.654

(d) PMI

Table 34: Top 5 For Cuisine: jewish

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
katsuoibushi	seaweed	5.383
kelp	enokidake	5.081
wasabi	seaweed	4.901
mussel	squid	4.358
turmeric	fenugreek	4.261

(b) COF

Ingredient 1	Ingredient 2	Score
beef	raw_beef	1.000
mackerel	eel	1.000
mung_bean	bean	1.000
mushroom	enokidake	0.990
mung_bean	black_bean	0.989

(c) SN

Ingredient 1	Ingredient 2	Score
katsuoibushi	seaweed	4.883
kelp	enokidake	4.638
wasabi	seaweed	4.401
mussel	squid	3.887
sake	katsuoibushi	3.793

(d) PMI

Table 35: Top 5 For Cuisine: korean

Ingredient 1	Ingredient 2	Score
egg	wheat	0.125
butter	wheat	0.111
turmeric	coriander	0.091
milk	wheat	0.085
garlic	tomato	0.075

(a) FPHF

Ingredient 1	Ingredient 2	Score
turmeric	coriander	3.715
cumin	coriander	3.009
roasted_sesame_seed	radish	2.885
cumin	turmeric	2.810
mint	lamb	2.789

(b) COF

Ingredient 1	Ingredient 2	Score
black_pepper	pepper	0.903
green_bell_pepper	pepper	0.899
nut	pistachio	0.883
black_pepper	green_bell_pepper	0.876
cayenne	green_bell_pepper	0.836

(c) SN

Ingredient 1	Ingredient 2	Score
turmeric	coriander	3.303
cumin	turmeric	2.678
cumin	coriander	2.623
roasted_sesame_seed	radish	2.413
mint	lamb	2.346

(d) PMI

Table 36: Top 5 For Cuisine: lebanon

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
galanga	thai_pepper	5.919
galanga	lemongrass	5.871
thai_pepper	lemongrass	4.869
turmeric	fenugreek	4.261
coriander	fenugreek	3.994

(b) COF

Ingredient 1	Ingredient 2	Score
thai_pepper	pepper	0.944
black_pepper	pepper	0.903
black_pepper	thai_pepper	0.896
thai_pepper	cayenne	0.874
cayenne	pepper	0.828

(c) SN

Ingredient 1	Ingredient 2	Score
galanga	thai_pepper	5.443
galanga	lemongrass	5.371
thai_pepper	lemongrass	4.406
turmeric	fenugreek	3.761
coriander	fenugreek	3.526

(d) PMI

Table 37: Top 5 For Cuisine: malaysia

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
turnip	parsnip	4.922
caraway	rye_flour	4.720
mussel	squid	4.358
turmeric	fenugreek	4.261
clam	mussel	4.084

(b) COF

Ingredient 1	Ingredient 2	Score
fish	haddock	0.984
mushroom	porcini	0.978
bacon	pork_sausage	0.972
cod	fish	0.970
cheese	feta_cheese	0.965

(c) SN

Ingredient 1	Ingredient 2	Score
turnip	parsnip	4.422
caraway	rye_flour	4.220
mussel	squid	3.887
turmeric	fenugreek	3.761
seed	caraway	3.654

(d) PMI

Table 38: Top 5 For Cuisine: mediterranean

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
bitter_orange	brandy	5.396
whiskey	bourbon_whiskey	5.211
turnip	parsnip	4.922
sweet_potato	yam	4.584
mussel	squid	4.358

(b) COF

Ingredient 1	Ingredient 2	Score
catfish	haddock	1.000
cheese	munster_cheese	0.998
wine	champagne_wine	0.994
fish	haddock	0.984
tuna	salmon	0.983

(c) SN

Ingredient 1	Ingredient 2	Score
bitter_orange	brandy	4.913
whiskey	bourbon_whiskey	4.738
turnip	parsnip	4.422
sweet_potato	yam	4.084
mussel	squid	3.887

(d) PMI

Table 39: Top 5 For Cuisine: mexican

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
caraway	rye_flour	4.720
sweet_potato	yam	4.584
turmeric	fenugreek	4.261
seed	caraway	4.063
coriander	fenugreek	3.994

(b) COF

Ingredient 1	Ingredient 2	Score
wine	champagne_wine	0.994
catfish	fish	0.982
cheese	feta_cheese	0.965
goat_cheese	cheese	0.961
goat_cheese	feta_cheese	0.947

(c) SN

Ingredient 1	Ingredient 2	Score
caraway	rye_flour	4.220
sweet_potato	yam	4.084
turmeric	fenugreek	3.761
seed	caraway	3.654
coriander	fenugreek	3.526

(d) PMI

Table 40: Top 5 For Cuisine: middleeastern

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
turnip	parsnip	4.922
caraway	rye_flour	4.720
sweet_potato	yam	4.584
turmeric	fenugreek	4.261
seed	caraway	4.063

(b) COF

Ingredient 1	Ingredient 2	Score
fish	haddock	0.984
cod	fish	0.970
cheese	feta_cheese	0.965
goat_cheese	cheese	0.961
goat_cheese	feta_cheese	0.947

(c) SN

Ingredient 1	Ingredient 2	Score
turnip	parsnip	4.422
caraway	rye_flour	4.220
sweet_potato	yam	4.084
turmeric	fenugreek	3.761
seed	caraway	3.654

(d) PMI

Table 41: Top 5 For Cuisine: moroccan

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	4.261
coriander	fenugreek	3.994
turmeric	coriander	3.715
cumin	fenugreek	3.304
cumin	coriander	3.009

(b) COF

Ingredient 1	Ingredient 2	Score
ham	veal	0.911
black_pepper	pepper	0.903
green_bell_pepper	pepper	0.899
black_pepper	green_bell_pepper	0.876
cheese	swiss_cheese	0.869

(c) SN

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	3.761
coriander	fenugreek	3.526
turmeric	coriander	3.303
cumin	fenugreek	2.840
blueberry	raspberry	2.714

(d) PMI

Table 42: Top 5 For Cuisine: netherlands

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
turnip	parsnip	4.922
turmeric	fenugreek	4.261
seed	caraway	4.063
coriander	fenugreek	3.994
turmeric	coriander	3.715

(b) COF

Ingredient 1	Ingredient 2	Score
cheese	feta_cheese	0.965
goat_cheese	cheese	0.961
cream_cheese	feta_cheese	0.948
cheese	cream_cheese	0.948
goat_cheese	feta_cheese	0.947

(c) SN

Ingredient 1	Ingredient 2	Score
turnip	parsnip	4.422
turmeric	fenugreek	3.761
seed	caraway	3.654
coriander	fenugreek	3.526
turmeric	coriander	3.303

(d) PMI

Table 43: Top 5 For Cuisine: north-african

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
coriander	fenugreek	0.121
turmeric	coriander	0.091
garlic	tomato	0.075
garlic	olive_oil	0.074

(a) FPHF

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	4.261
coriander	fenugreek	3.994
turmeric	coriander	3.715
cumin	fenugreek	3.304
cumin	coriander	3.009

(b) COF

Ingredient 1	Ingredient 2	Score
beef	roasted_beef	0.905
black_pepper	pepper	0.903
green_bell_pepper	pepper	0.899
black_pepper	green_bell_pepper	0.876
cayenne	green_bell_pepper	0.836

(c) SN

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	3.761
coriander	fenugreek	3.526
turmeric	coriander	3.303
cumin	fenugreek	2.840
cumin	turmeric	2.678

(d) PMI

Table 44: Top 5 For Cuisine: pakistan

Ingredient 1	Ingredient 2	Score
egg	wheat	0.125
butter	wheat	0.111
milk	wheat	0.085
garlic	tomato	0.075
garlic	olive_oil	0.074

(a) FPHF

Ingredient 1	Ingredient 2	Score
chive	cucumber	3.072
sake	soy_sauce	3.033
cumin	coriander	3.009
celery_oil	corn	2.979
celery_oil	tamarind	2.942

(b) COF

Ingredient 1	Ingredient 2	Score
pork	roasted_pork	0.966
pork	pork_sausage	0.946
roasted_pork	pork_sausage	0.934
cheese	mozzarella_cheese	0.905
black_pepper	pepper	0.903

(c) SN

Ingredient 1	Ingredient 2	Score
cumin	coriander	2.623
radish	sake	2.577
chive	cucumber	2.572
sake	soy_sauce	2.533
celery_oil	corn	2.479

(d) PMI

Table 45: Top 5 For Cuisine: philippines

Ingredient 1	Ingredient 2	Score
egg	wheat	0.125
butter	wheat	0.111
milk	wheat	0.085
garlic	tomato	0.075
garlic	olive_oil	0.074

(a) FPHF

Ingredient 1	Ingredient 2	Score
smoke	smoked_sausage	3.140
celery_oil	corn	2.979
chickpea	kidney_bean	2.892
smoke	ham	2.845
kidney_bean	bean	2.768

(b) COF

Ingredient 1	Ingredient 2	Score
bacon	pork_sausage	0.972
cod	fish	0.970
pork	pork_sausage	0.946
bacon	pork	0.932
kidney_bean	bean	0.928

(c) SN

Ingredient 1	Ingredient 2	Score
smoke	smoked_sausage	2.700
smoked_sausage	pork_sausage	2.567
celery_oil	corn	2.479
chickpea	kidney_bean	2.392
smoke	ham	2.345

(d) PMI

Table 46: Top 5 For Cuisine: portugal

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
bitter_orange	brandy	5.396
whiskey	bourbon_whiskey	5.211
turnip	parsnip	4.922
caraway	rye_flour	4.720
turmeric	fenugreek	4.261

(b) COF

Ingredient 1	Ingredient 2	Score
herring	fish	0.984
salmon	smoked_salmon	0.979
bacon	pork_sausage	0.972
pork	roasted_pork	0.966
cheese	cream_cheese	0.948

(c) SN

Ingredient 1	Ingredient 2	Score
bitter_orange	brandy	4.913
whiskey	bourbon_whiskey	4.738
turnip	parsnip	4.422
caraway	rye_flour	4.220
turmeric	fenugreek	3.761

(d) PMI

Table 47: Top 5 For Cuisine: scandinavian

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	4.261
coriander	fenugreek	3.994
turmeric	coriander	3.715
cumin	fenugreek	3.304
cumin	coriander	3.009

(b) COF

Ingredient 1	Ingredient 2	Score
black_pepper	pepper	0.903
bread	white_bread	0.855
cayenne	pepper	0.828
black_pepper	cayenne	0.762
meat	lamb	0.650

(c) SN

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	3.761
coriander	fenugreek	3.526
turmeric	coriander	3.303
cumin	fenugreek	2.840
cumin	turmeric	2.678

(d) PMI

Table 48: Top 5 For Cuisine: south-african

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	4.261
coriander	fenugreek	3.994
turmeric	coriander	3.715
cumin	fenugreek	3.304
olive	pimento	3.149

(b) COF

Ingredient 1	Ingredient 2	Score
bacon	pork_sausage	0.972
bean	black_bean	0.960
pork	pork_sausage	0.946
thai_pepper	pepper	0.944
bacon	pork	0.932

(c) SN

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	3.761
coriander	fenugreek	3.526
turmeric	coriander	3.303
cumin	fenugreek	2.840
olive	pimento	2.690

(d) PMI

Table 49: Top 5 For Cuisine: south-america

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
lavender	savory	6.173
whiskey	bourbon_whiskey	5.211
turnip	parsnip	4.922
sweet_potato	yam	4.584
turmeric	fenugreek	4.261

(b) COF

Ingredient 1	Ingredient 2	Score
wine	champagne_wine	0.994
catfish	fish	0.982
cottage_cheese	cream_cheese	0.980
salmon	smoked_salmon	0.979
red_kidney_bean	lima_bean	0.975

(c) SN

Ingredient 1	Ingredient 2	Score
lavender	savory	5.673
whiskey	bourbon_whiskey	4.738
turnip	parsnip	4.422
sweet_potato	yam	4.084
turmeric	fenugreek	3.761

(d) PMI

Table 50: Top 5 For Cuisine: southern soulfood

Ingredient 1	Ingredient 2	Score
egg	wheat	0.125
butter	wheat	0.111
milk	wheat	0.085
garlic	tomato	0.075
garlic	olive_oil	0.074

(a) FPHF

Ingredient 1	Ingredient 2	Score
mussel	squid	4.358
clam	mussel	4.084
sage	marjoram	3.824
lime_juice	lime_peel_oil	3.823
lima_bean	kidney_bean	3.758

(b) COF

Ingredient 1	Ingredient 2	Score
red_kidney_bean	lima_bean	0.975
bacon	pork_sausage	0.972
cheese	feta_cheese	0.965
goat_cheese	cheese	0.961
bean	black_bean	0.960

(c) SN

Ingredient 1	Ingredient 2	Score
mussel	squid	3.887
clam	mussel	3.638
sage	marjoram	3.424
lime_juice	lime_peel_oil	3.400
lima_bean	kidney_bean	3.302

(d) PMI

Table 51: Top 5 For Cuisine: southwestern

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
mussel	squid	4.358
turmeric	fenugreek	4.261
clam	mussel	4.084
coriander	fenugreek	3.994
turmeric	coriander	3.715

(b) COF

Ingredient 1	Ingredient 2	Score
bacon	pork_sausage	0.972
cod	fish	0.970
bean	black_bean	0.960
cheese	cream_cheese	0.948
pork	pork_sausage	0.946

(c) SN

Ingredient 1	Ingredient 2	Score
mussel	squid	3.887
turmeric	fenugreek	3.761
clam	mussel	3.638
coriander	fenugreek	3.526
turmeric	coriander	3.303

(d) PMI

Table 52: Top 5 For Cuisine: spain

Ingredient 1	Ingredient 2	Score
egg	wheat	0.125
butter	wheat	0.111
turmeric	coriander	0.091
milk	wheat	0.085
garlic	tomato	0.075

(a) FPHF

Ingredient 1	Ingredient 2	Score
bitter_orange	brandy	5.396
sweet_potato	yam	4.584
mussel	squid	4.358
bay	lovage	4.145
crab	lovage	4.092

(b) COF

Ingredient 1	Ingredient 2	Score
wine	champagne_wine	0.994
mushroom	porcini	0.978
bacon	pork_sausage	0.972
cod	fish	0.970
cheese	feta_cheese	0.965

(c) SN

Ingredient 1	Ingredient 2	Score
bitter_orange	brandy	4.913
sweet_potato	yam	4.084
mussel	squid	3.887
bay	lovage	3.645
clam	mussel	3.638

(d) PMI

Table 53: Top 5 For Cuisine: spanish portuguese

Ingredient 1	Ingredient 2	Score
egg	wheat	0.125
butter	wheat	0.111
milk	wheat	0.085
garlic	tomato	0.075
wheat	vanilla	0.074

(a) FPHF

Ingredient 1	Ingredient 2	Score
seed	anise	2.872
cherry	brandy	2.496
cherry	citrus	2.379
beef_broth	red_wine	2.351
bay	beef_broth	2.334

(b) COF

Ingredient 1	Ingredient 2	Score
black_pepper	pepper	0.903
cheese	swiss_cheese	0.869
red_wine	white_wine	0.661
lemon	citrus	0.647
bread	wheat_bread	0.566

(c) SN

Ingredient 1	Ingredient 2	Score
seed	anise	2.372
cherry	citrus	2.090
cherry	brandy	2.028
beef_broth	red_wine	1.857
bay	beef_broth	1.834

(d) PMI

Table 54: Top 5 For Cuisine: switzerland

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
galanga	thai_pepper	5.919
galanga	lemongrass	5.871
thai_pepper	lemongrass	4.869
sweet_potato	yam	4.584
mussel	squid	4.358

(b) COF

Ingredient 1	Ingredient 2	Score
tuna	salmon	0.983
catfish	fish	0.982
pork	roasted_pork	0.966
peanut_butter	roasted_peanut	0.962
bean	black_bean	0.960

(c) SN

Ingredient 1	Ingredient 2	Score
galanga	thai_pepper	5.443
galanga	lemongrass	5.371
thai_pepper	lemongrass	4.406
sweet_potato	yam	4.084
mussel	squid	3.887

(d) PMI

Table 55: Top 5 For Cuisine: thai

Ingredient 1	Ingredient 2	Score
egg	wheat	0.125
butter	wheat	0.111
milk	wheat	0.085
garlic	tomato	0.075
garlic	olive_oil	0.074

(a) FPHF

Ingredient 1	Ingredient 2	Score
mint	lamb	2.789
macaroni	mozzarella_cheese	2.211
mint	yogurt	2.168
milk_fat	milk	1.996
yogurt	strawberry	1.969

(b) COF

Ingredient 1	Ingredient 2	Score
cream_cheese	mozzarella_cheese	0.931
black_pepper	pepper	0.903
green_bell_pepper	pepper	0.899
black_pepper	green_bell_pepper	0.876
cayenne	green_bell_pepper	0.836

(c) SN

Ingredient 1	Ingredient 2	Score
mint	lamb	2.346
macaroni	mozzarella_cheese	1.719
mint	yogurt	1.668
yogurt	lamb	1.594
yogurt	strawberry	1.537

(d) PMI

Table 56: Top 5 For Cuisine: turkey

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
lavender	savory	6.173
whiskey	bourbon.whiskey	5.211
turnip	parsnip	4.922
turmeric	fenugreek	4.261
lavender	fennel	4.220

(b) COF

Ingredient 1	Ingredient 2	Score
bacon	pork_sausage	0.972
cheese	cream_cheese	0.948
pork	pork_sausage	0.946
cod	haddock	0.942
bacon	pork	0.932

(c) SN

Ingredient 1	Ingredient 2	Score
lavender	savory	5.673
whiskey	bourbon.whiskey	4.738
turnip	parsnip	4.422
turmeric	fenugreek	3.761
lavender	fennel	3.757

(d) PMI

Table 57: Top 5 For Cuisine: uk-and-ireland

Ingredient 1	Ingredient 2	Score
thai_pepper	lemongrass	4.869
turmeric	fenugreek	4.261
coriander	fenugreek	3.994
turmeric	coriander	3.715
turmeric	coriander	3.304

(a) FPHF

Ingredient 1	Ingredient 2	Score
thai_pepper	bean	1.000
catfish	fish	0.982
thai_pepper	tabasco_pepper	0.949
shiitake	mushroom	0.946
thai_pepper	pepper	0.944

(b) COF

Ingredient 1	Ingredient 2	Score
thai_pepper	lemongrass	4.869
turmeric	fenugreek	4.261
coriander	fenugreek	3.994
turmeric	coriander	3.715
turmeric	coriander	3.304

(c) SN

Ingredient 1	Ingredient 2	Score
thai_pepper	lemongrass	4.406
turmeric	fenugreek	3.761
coriander	fenugreek	3.526
turmeric	coriander	3.303
shiitake	oyster	2.902

(d) PMI

Table 58: Top 5 For Cuisine: vietnamese

Ingredient 1	Ingredient 2	Score
egg	wheat	0.125
butter	wheat	0.111
garlic	tomato	0.075
garlic	olive_oil	0.074
garlic	cayenne	0.064

(a) FPHF

Ingredient 1	Ingredient 2	Score
cumin	coriander	3.009
peanut_butter	roasted_peanut	2.860
rosemary	thyme	2.693
tamarind	cane_molasses	2.465
chickpea	cumin	2.392

(b) COF

Ingredient 1	Ingredient 2	Score
peanut_butter	roasted_peanut	0.962
rice	brown_rice	0.943
black_pepper	pepper	0.903
green_bell_pepper	pepper	0.899
black_pepper	green_bell_pepper	0.876

(c) SN

Ingredient 1	Ingredient 2	Score
cumin	coriander	2.623
peanut_butter	roasted_peanut	2.367
rosemary	thyme	2.345
tamarind	cane_molasses	1.965
tamarind	vinegar	1.921

(d) PMI

Table 59: Top 5 For Cuisine: west-african

Ingredient 1	Ingredient 2	Score
turmeric	fenugreek	0.174
egg	wheat	0.125
coriander	fenugreek	0.121
butter	wheat	0.111
turmeric	coriander	0.091

(a) FPHF

Ingredient 1	Ingredient 2	Score
mussel	squid	4.358
turmeric	fenugreek	4.261
shiitake	enokidake	4.223
radish	enokidake	4.220
clam	mussel	4.084

(b) COF

Ingredient 1	Ingredient 2	Score
cheese	emmental_cheese	1.000
mushroom	enokidake	0.990
jamaican_rum	rum	0.983
tuna	salmon	0.983
mackerel	fish	0.980

(c) SN

Ingredient 1	Ingredient 2	Score
mussel	squid	3.887
radish	enokidake	3.768
turmeric	fenugreek	3.761
shiitake	enokidake	3.739
clam	mussel	3.638

(d) PMI

Table 60: Top 5 For Cuisine: western