SPOONSHOT®

LET'S TALK FLAVOR PAIRING

Flavor encompasses both aroma and taste, which is the defining characteristic of how we taste food.

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SUMMARY

Strawberries on burgers? Vanilla tamarind ice-cream? These combinations may, at first, seem like they wouldn't go together, but can turn out to be spectacular new taste sensations.

Wondering how? Flavor encompasses both aroma and taste, which is the defining characteristic of how we taste the food. The flavor is created by receptors in the mouth and nose, discovering chemicals found within food. These receptors respond by processing signals that are deciphered by the brain as sensations of taste and aroma.

For example, tamarind tastes the way it does because of the unique combination of chemicals found naturally within it and perceived by our tongues, noses, and brains as the distinct blend of sweet and sour tastes, and volatile aromas characteristic to the fruit.

THE
UNDERLYING
PROBLEM

Today, product developers and innovators in the food industry are continually trying to come up with new flavors that will appeal to consumers. However, there is no way to be sure that a particular flavor or flavor combination will work for your product. At Spoonshot, we have mastered the art and science to unveil novel flavor combinations using AI-technology. We have built an AI-powered insights platform fused with food science to provide customer intelligence on future trends and new product or flavor opportunities for CPG companies.

HOW DOES AI AND FOOD SCIENCE BLEND

The confluence of AI and fundamental sciences has led to the building of many powerful applications, e.g., aeronautical simulations, physics engine, and drug discovery, to name a few. Formulations of the problem are done by using the principles of science and then later solved using AI techniques. This is a compelling paradigm for problem-solving as it retains the explainability factor because fundamental sciences have got strong theoretical foundations.

The internet is an enormous collection of connected dots of information. However, here's the thing, those connections are not visible, and the number of dots is growing at an exponential rate. At Spoonshot, we use AI techniques, like Natural Language Processing and Computer Vision technologies, to build structured information from unstructured data. We do this by leveraging food science principles to establish relationships between these information dots. Depending on the application or insight that is delivered, the appropriate datasets and connection types are used.

We collect information relating to the physical and chemical properties of ingredients and understand how ingredient interactions impact a final recipe, to build insights that are valid and relevant to you. Currently, our database contains volatile compounds for each ingredient, their sensory flavor profile, and the nutritional breakdown of ingredients. We use publicly available data, e.g., web, academic articles, and patents, to get this information.

Without the detailed flavor profile or chemical breakdown of an ingredient, it is tough to relate seemingly unrelated ingredients to each other, e.g., sugar, bananas, and strawberries all contain varying amounts of sugars and therefore, can be considered sweet.

A DEEPER LOOK AT FLAVOR PAIRING

A hypothesis, which over the past decade has received attention among some chefs and food scientists, states that ingredients sharing flavor compounds are more likely to taste well together than ingredients that do not.

To understand if a combination of ingredients will be a good flavor match, we first need to get data regarding the flavor profile of ingredients and understand their role in any particular formulation. The flavor profile of ingredients includes the volatile compounds and the dominant aroma/taste of a specific ingredient.

Findings by Ahn et al. further indicate that Western cuisines show a tendency to use ingredient pairs that share many flavor compounds, supporting the so-called food pairing hypothesis. By contrast, East Asian cuisines tend to avoid compound sharing ingredients. Therefore, this could be one way of discovering ingredient pairs that are appealing to the Western consumer.

Some of the unique combinations that have emerged through traditional flavor pairing are blue cheese and chocolate*, and strawberry and basil. If we can tag ingredients with their respective dominant sensory descriptors, the prediction of new flavor combinations could become even more useful.

* The Fat duck cook book by Blumenthal Heston

EXAMPLE:
AROMA COMPOUNDS + AROMA DESCRIPTORS

Ingredient:
All-Spice

Descriptors:
Sweet, hot, pungent, spicy, pepper,
cinnamon, clove, cumin, mace, nutmeg

Ingredient:
Bay Leaf

Descriptors:
Bitter, sweet, aromatic, pungent, spicy,
clove, flowers, grass, spearmint, nutmeg,
pepper, pine, wood

If you look at the dominant descriptors for the above two ingredients, you can see that they share six of their descriptors, which would indicate that these two ingredients may go well together.

When analyzing the top 10 ingredients that go well with each ingredient in our database, we found that 32% of the ingredients show significant changes in their top flavor matches when using both aroma compounds and their descriptors rather than just using aroma compounds. Therefore, you can get a more accurate result when adding aroma compounds and their descriptors.

Let's look at another example - Vanilla. The top 10 ingredients that go well with vanilla are listed here, where the aroma compound pairing suggests that fruits go well with vanilla. There is an increase in the diversity of ingredients with the inclusion of descriptor pairings.

Ingredients in a particular ingredient family would share a lot of similar compounds; therefore, when using only the compound pairing theory, you can expect to get a relatively less diverse set of top flavor matches. Also, because these descriptors represent the dominant flavors in the particular ingredient, using both descriptors and compounds should be more accurate.

32%
OF THE INGREDIENTS

VANILLA

AROMA COMPOUND PAIRING

Red apple

Pineapple

Tomato

Strawberry

Cocoa bean

Passion fruit

Papaya

Banana

Mango

Guava

AROMA COMPOUND + AROMA DESCRIPTOR PAIRING

Hazelnut

Walnut

Lima beans

Thyme

Rosemary

Sage

Cumin seeds

Star anise

Cinnamon

Marjoram

There are other generalizations about flavor pairing that can be used to predict combinations better. Over the years, chefs have talked about balancing and complementary pairs. For example, we all know that sweet ingredients complement spicy, sour, and balance out bitter ingredients. These generalizations could be another way to discover new pairs that go well together.

Even with the addition of aroma descriptors, the flavor pairing theory is limited in predicting ingredients that go well together. Research has shown that contrasting flavor profiles are more likely to be used in recipes in Asian cuisine.

Therefore, though the flavor pairing theory can be useful in predicting ingredients that could work well together, it can never be the only reason why ingredients are used together.

There is more to using flavor agents than just their similarity of flavor profiles. Herbs and spices have been historically used for their antimicrobial activity or to prevent spoilage of food. Some researchers have found a correlation between the frequency in the use of spices and the climate of the country. Other flavors such as sweet and umami ingredients have evolutionarily been used because they are indicators of calorie-rich, healthy food.

Since there are multiple reasons for using flavor ingredients in a particular recipe, we have to find alternatives to be able to mathematically calculate whether two ingredients go well together in terms of their flavor.

What if we could understand the role of ingredients in recipes to then dive deeper into the creative space of the formulation to recognize which ingredients are commonly used together, particularly for their flavor.

BLUEPRINT OF RECIPES

We have divided our recipe and ingredient database (> 1.2 million recipes, approximately 5,000 natural ingredients) into several categories.

For each recipe type, we first define ingredient families that make up the functional component of the formulation and also include signature ingredients inthe particular recipe. For example,

1.2M
RECIPES

10K
INGREDIENTS

Recipe Type:
Cake

Ingredient Families (functional):
Flour, Dairy Fat, Egg, and Sugar or Sweetener, Leavening Agent

Recipe Type:
Pizza

Ingredient Families (functional):
Flour, Leavening Agent

Ingredient Families (signature):
Cheese

IMPACT OF BLUEPRINT RECIPES ON INGREDIENT FLAVOR MATCH SCORES

1,868
INGREDIENTS

A lot of non-creative or functional ingredients show up in the top 10 ingredients when deciding the flavor matches without the blueprint. The use of blueprint recipes has an impact on 1,868 ingredients' top 10 flavor matches.

SUGAR'S TOP 10 MATCHES

Without Blueprint

- Salt
- Butter
- Eggs
- Water
- Milk
- Vanilla essence
- All-purpose flour
- Plain flour
- Baking powder
- Lemon

With Blueprint

- Vegetable oil
- Vinegar
- Buttermilk
- Tomato
- Extra virgin olive oil
- Condensed milk
- Thyme
- Wheat flour
- Vanilla
- Vanilla essence *

* Repeated in both

MOZZARELLA CHEESE'S TOP 10 MATCHES

Without Blueprint

- Salt
- Water
- Garlic
- Oilve oil
- Black pepper
- Sugar
- Plain flour
- Yeast
- Parmesan cheese
- Tomato

With Blueprint

- Tomato *
- Olive oil *
- Onions
- Sugar *
- Extra virgin olive oil
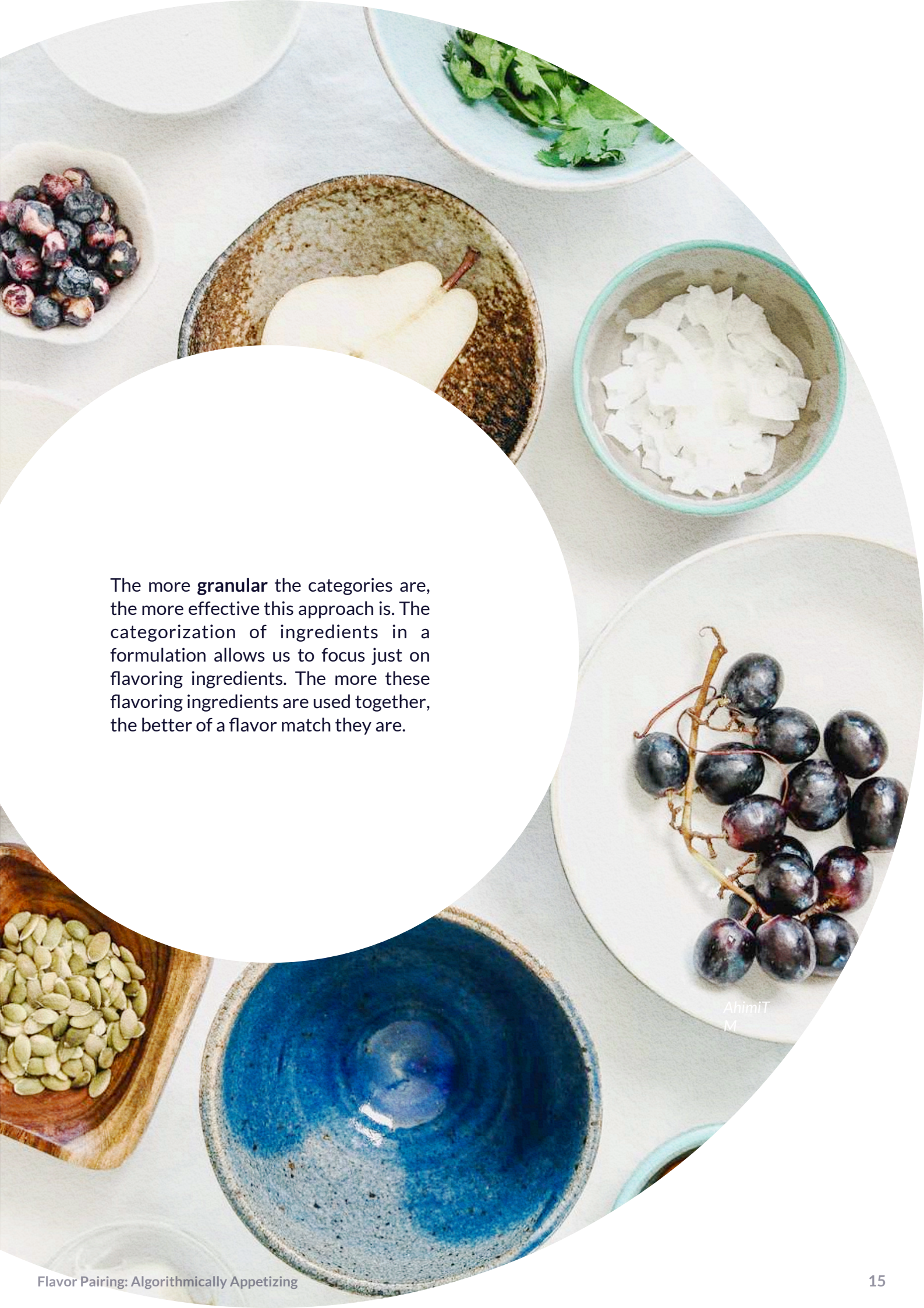- Parmesan cheese *
- Parsley
- Oregano
- Sea salt
- Plain flour *

* Repeated in both

The more **granular** the categories are, the more effective this approach is. The categorization of ingredients in a formulation allows us to focus just on flavoring ingredients. The more these flavoring ingredients are used together, the better of a flavor match they are.

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WHY DOES THIS APPROACH WORK?

Finding patterns in formulations and why two ingredients are used together is complex. Synergistic flavors are more likely to be used together and work well (at least for the Western palette). However, this is not the only reason ingredients pair well together. Contrasting flavors are sometimes needed in a recipe to balance out strong, dominant ingredients.

A rich recipe database from across the world allows us to account for these "other" factors. The one downside of this approach is that the prediction of new ingredient flavor matches is not theoretically possible to do when looking for frequency of ingredients in recipes.

To predict new ingredient matches, determining adjacency of ingredients will be essential. Tagging ingredients with benefits, their functional/flavoring role, and a recipe database might allow us to find relevant patterns. Therefore, more research is required to find better, universal solutions.

LOOKING AHEAD

Overall, it is essential to understand that the 'whys' of flavor combinations are very varied. To discover new and accurate pairs, we have to use a multitude of approaches. Tagging the origin of flavors, their health benefits, and determining adjacency of ingredients will be critical to improving the prediction of a flavor match further.

To predict a trio of ingredients or full-fledged recipes, a more nuanced theory explaining the use of ingredients in a variety of cuisines will be useful. Research has suggested that when two ingredients (A, B) do not share aroma compounds, the use of an ingredient C that shares aroma compounds with both A and B makes the combination more likely to occur in recipes.

Also, to recommend complete recipes, we would have to include functional ingredients as well, which would mean understanding the texture compatibility of ingredients.

ABOUT SPOONSHOT

Spoonshot is a food AI company that is raising the bar for insight-led innovation. Spoonshot's belief is that exploration is the catalyst behind the novel, successful products, the very fuel to help food and beverage companies shape the future, toset the trend.

Spoonshot equips the food and beverage industry with unprecedented foresight of emerging market needs. By transforming long-tail, open information from diverse, authentic sources, Spoonshot's proprietary food science infused algorithms connect disparate data sets, to deliver personalized insights, predict trends, and identify novel opportunities. Today, Spoonshot is supporting the world's best-known brands in meeting the future needs of its customers. For more information, please visit **spoonshot.com.**

To request a demo of our AI-powered insights platform, send us an email at **hello@spoonshot.com**

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