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UTILIZATION OF FLAVOR NETWORK ANALYSIS FOR A NEW RECIPE IN MARMARA REGION

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ABSTRACT

Natural flavor compounds give natural taste and odor characteristics to the food ingredients. According to food pairing theory, ingredients that contain higher number of shared flavor compounds go well together in a dish. In this study, flavor network analysis was used to create a new food in Marmara Region by evaluating the ingredient pairs based on number of shared compounds. A new dessert with four main ingredients, rice, milk, bean and figs that shared higher number of flavor compounds was formulated. Among the flavour compounds, eight of them were common in all four ingredients and they interestingly had similar taste and odor characteristics which showed how flavor pairing worked well in design of new dish. According to 9-point hedonic scale of consumer preference test, 80% of 20 panelists extremely liked the dish. Knowledge on flavour science and food pairing theory will pave the way to create highly preferable food formulations.

Keywords: Network analysis, flavor compounds, new recipe, sensory characteristics, Marmara region

MARMARA BÖLGESİNDE YENİ BİR TATLI TARİFİ İÇİN LEZZET BİLEŞİKLERİ AĞ ANALİZİNİN KULLANIMI

ÖZ

Doğal lezzet bileşikleri gıda malzemelerine karakteristik tat ve koku özelliklerini vermektedir. Gıda eşleştirme teorisine göre, yüksek sayıda ortak lezzet bileşiği içeren gıda malzemeleri birbiriyle uyum içerisinde güzel tat veren bir yemek oluşturabilir. Bu çalışmada, Marmara Bölgesi'nde yeni bir tarif oluşturmak için, malzemeler içerdikleri ortak bileşik sayısına göre değerlendirilip tat bileşikleri ağ analizi metodu kullanıldı. Yüksek sayıda ortak bileşik içeren eşleştirmelerden pirinç, süt, kuru fasulye ve incir malzemelerini ihtiva eden yeni bir tatlı geliştirildi. Ortak bileşiklerden sekiz tanesinin dört malzemede de bulunduğu ve şaşırtıcı bir şekilde birbiriyle benzer tat ve koku maddeleri içerdiği görüldü ki bu da lezzet eşleştirme teorisinin bu bölgedeki yeni bir tarif için kullanılabildiğini göstermektedir. 9-noktalı hedonik skala testine göre, 20 panelistin %80'i 'Fevkalade beğendim' seçeneğini işaretlemiştir. Lezzet bilimi ve gıda eşleştirme teorisinin bilinmesi, tüketimi çok tercih edilen yeni gıda formülasyonlarının geliştirilmesi imkânını bize verebilecektir.

Anahtar kelimeler: Ağ analizi, lezzet bileşikleri, yeni tarif, duyusal özellikler, Marmara Bölgesi

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INTRODUCTION

Flavor, the common sensory attribute, can be used to describe the harmony of aroma and taste of any food and beverage. Taste can be perceived by taste buds and aroma can be perceived by olfactory nerves in the nose. Moreover some other sensory attributes such as mouthfeel, even emotions, thoughts, and spirits can also play role to determine the flavor of any dish by human beings (Dornenburg and Page, 2008). Flavor compounds are chemical compounds including volatile and nonvolatiles that give odor and taste characteristics to the foods and beverages (Burdock, 2009; Reineccius, 2006). They can be formed upon various physical and biochemical reactions during planting, harvesting and processing of any food material or due to the intentional use of microbial catalysts (Reineccius, 2006; Taylor and Hort, 2007).

Methods of digitalization help to process big data in culinary science and convert it into more understandable mapped form that can be used efficiently by online end-users (Mouritsen et al., 2017; Pinel et al., 2015). Starting from the birth of Industry 4.0, the most recent industrial revolution worldwide, the use of digital technologies (i.e. big data, data mining, internet of things, cyber-physical systems, intelligent information technologies) have been increased at various disciplines (Geissbauer et al., 2016; Toroa et al., 2015). Digitalism took role different applications in food related area such as 3-D food printing, developing culinary ontologies, digital control of food production lines using artificial intelligence, etc. (Ergün Öztürk and Öztürk, 2018; Ghaswala et al., 2018; Higgings, 2017; Kutup, 2017; McNamara, 2017; Mizrahi et al., 2016). One of the application areas of digitalism in gastronomy field is the use of network science in creating new recipes and it was stated that computational gastronomy seemed be a promising field that will facilitate to cope with the increased digitatized data in food science. Therefore, new term computational gastronomy or digital gastronomy has been developed by the researchers as a new interdisciplinary scientific field (Ahnerts, 2013; Kutup, 2017; Mizrahi et al., 2016) .

Network analysis method is based on network theory that states the analysis of relations of elements that have some connection between one another through mathematical graphs (Shrinivas et al. 2010). It is widely used in computer sciences, but also applicable in many different research fields, such as genetics and bioengineering, medicine, ecology, food science and gastronomy, social sciences, and management etc. (Ahn et al., 2011; Ahnert, 2013; Barabási et al., 2011; Borgatti et al., 2009; Dunne et al., 2002; Habibi et al., 2014). One of the best application areas of network analysis in food science is its utilization in food and flavor pairing so as appeared in the example of 'Foodpairing.be' created by Bernhard Lahousse and Lieven de Couvreux (Kort et al., 2010). Flavor perception and pairing of unusual ingredients are recent interested topics of gastronomy researches. Indeed, there has been a hypothesis developed for creating new dishes by the chefs Henson Blumental and Francois Benzi in 1992, stating that 'ingredients would taste well together in a dish if they share common flavor compounds'. This hypothesis helped Chef Blumenthal to create unique tastes of dishes that consumers highly preferred and consequently paved the way to receive 3 Michelin stars for his restaurant 'The Fat Duck' (Blumenthal, 2009). Flavor network analysis was described as the method of analyzing the pairs of ingredients in terms of common flavor compounds they contain. In this method, pairings were formed by constructing a one mode projection of bipartite network of food ingredients in which a link signified the natural occurence of a chemical flavor compound in an ingredient (Ahnerts, 2013).

There have been limited studies on flavor pairing of different cuisines in worldwide, and in our study the use of flavor network analysis in the recipes of Marmara region in Turkey was the target. Marmara Region has two sides, Anatolia and Trace separated by the Bosphorus, and is surrounded by Black Sea Region and Central Anatolia Region in the east, Aegean Region in the south, and Greece and Bulgaria in the northwest (Şengül et al., 2015). Istanbul, the cosmopolitan city having the highest population of Turkey is

located in this region. An abundant culinary understanding developed by the combination of Anatolian and Rumelia cultures in the city Edirne and the effect of Rumelia and Balkan immigrants in Bursa cuisine all contributed to the diversity of ingredients and related dishes within this region. The richness and diversity that the geography offers are reflected in the culinary culture of the region (Akkor, 2009; Bozis, 2002; Halici, 1990; Şengül et al., 2015).

In this study, it was aimed to create a new dish by utilization of flavor network analysis to find the possible pairings of ingredients that are used in food recipes in Marmara Region, and conduct sensory evaluation of new dish using hedonic scale of consumer preference and questionnaire methods.

MATERIALS AND METHODS

Materials

Rice, dried beans, milk and fig are purchased from Metro Grossmarket in Istanbul. The utensils used to cook the dessert were found in the execution kitchen of the department.

Methods

Selection of food recipes and ingredients in Marmara region

Recipes of different meal groups consumed in Marmara Region were searched and recipes from soups, main dishes, salads, and desserts were decided to be selected to provide diversity of different tastes. Piyaz (Bean Salad), Cerkez Tavugu (Circassian chicken), Ayvali Et (Meat with quince), Terbiyeli suyu kofte (Seasoned sauce meatballs), Tekirdag Meatballs, Pirasa Dolmasi (Stuffed Leek), Firinda koy tabagi (Country Dish in the Kiln), Kayisili Uzumlu Pilav (Rice with apricot and raisin), Zerde, Nohutlu Manti (Ravioli with Chickpeas), Bulgurlu Sut Corbasi (Milk soup with Bulgur), Incir Dolmasi (Stuffed Figs) were the analyzed recipes taken from the reference book called "Marmara Bolgesi Yemekleri" (Bayrak, 2015).

Data mining and flavor network analysis for a new plate design

Each ingredient in the chosen recipes was scanned in the Fenaroli's Handbook of Flavor Ingredients (Burdock, 2009). The book tabulates the flavor compounds, their taste and odor threshold values, and the food materials in those the compounds exist. Names of flavor compounds of selected ingredients of the chosen recipes were extracted from this reference one by one, and were meticulously listed. After all, common flavor compounds among the ingredients were determined and a matrix chart was formed.

A flavor network diagram was designed illustrating the relations of individual ingredients on their own with regard to the flavor compounds they share with the links. The width of each link was determined by the number of shared compounds between individuals. The higher the number of shared compounds the wider the links between two ingredients. A new dish was planned to be developed by considering the ingredients that shared highest number of flavor compounds among the scanned ones.

Sensory evaluation of consumer preference

Consumer preference of the new dish was evaluated using a nine-point hedonic scale of sensory evaluation method (Pimentel et al., 2016). The new dish was served to twenty volunteer students (9 females and 11 males) at the department. The taste of the new dessert was asked to be evaluated based on overall liking level. A questionnaire to be filled out by each student was prepared including the questions, such as if they liked to experience new tastes, knew about flavor compounds, and if there was a similarity between the local tastes they had before, if they would order this meal on a menu of a restaurant.

RESULTS AND DISCUSSION

Food recipes from Marmara Region

Recipes were chosen according to the number and variety of ingredients they contained and from different dish groups, such as desserts, salads and main dishes using the reference book of Marmara Bolgesi Yemekleri (Bayrak, 2015).

Among them eight recipes; Bulgurlu süt çorbasi (Milk soup with Bulgur), Piyaz (Bean Salad), Terbiyeli sulu kofte (Seasoned sauce meatballs), Tekirdag Meatballs, Pirasa Dolmasi (Stuffed Leek), Kayisili Uzumlu Pilav (Rice with apricot and raisin), Zerde, Incir Dolmasi (Stuffed Figs) were chosen for this study due to the diverse and higher number of ingredients they included (Table 1). The Turkish measuring units in the recipes were converted into equivalent values of international volumetric and weight basis unit system. For example, Turkish style tea glass used as volumetric measuring unit was converted into international unit on weight basis (i.e. 1 tea glass of bulgur equals to 80 g bulgur).

Table 1. Ingredients of selected recipes from Marmara Region (Bayrak, 2015)

Milk soup with Bulgur	*Rice with apricot and raisin*	*Bean Salad*	*Zerde Dessert*
200-300 g chicken meat	2 cups of rice	1.5 cups dry bean	¼ cup of rice
80 g bulgur	2-3 dried apricots	0.5 cup olive oil	2-3 dried apricots
4 cups milk	2 Tsps raisins	2 eggs (boiled)	6 cups water
Salt	1 onion		2 Tsps wheat starch
	3 Tsps butter	2 onions	120 g sugar
	3 cups of beef stock or water	Half bunch parsley	2 Tsps of rose water
	1 tsp cinnamon	7-8 olives	2 Tsps of blackcurrant
	2 thin slices of lemon	Juice of 1.5 lemon	2 Tsps of pine nuts
	Salt	Salt	1 tsp turmeric or saffron
Seasoned sauce meatballs	*Tekirdağ Meatballs*	*Stuffed Leek*	*Stuffed Figs*
1 cellery	500 g ground beef	500 g leek	20 pieces of dried figs
1 carrot	1 onion	200 g of ground mutton	2 cups of walnuts
1 onion	1 slice of bread	1 onion	80 ml grape molasses
200 g. ground mutton	1 clove of garlic	2 Tsps rice	1 cup of water
2 Tsps of rice	1 tsp cumin	Half a bunch of parsley	
2 tablespoons of flour	A pinch of sodium bicarbonate	1 egg yolk	
2 potatoes	1 tsp black pepper	Juice of half lemon	
1 lemon juice	1 tsp red pepper flakes	Salt	
1 egg yolk	Salt	Black pepper	
Half a bunch of parsley			
Salt			
Black pepper			

*Tsp: tablespoon; tsp: teaspoon.

The ingredients from the chosen recipes were determined according to their existence in the book Fenaroli's Handbook of Flavor Ingredients the main comprehensive handbook in the literature (Burdock, 2009). For this aim, sixteen ingredients of these dishes were scanned and the ingredients, celery, carrots, leeks, rice, potatoes, eggs, beef, black currants, dried beans, pumpkin, yoghurt, figs, apricots, onion, chicken and milk existed in the natural occurrence section in the table of the flavor compounds (Burdock, 2009). The names and numbers of chemical compounds for each ingredient were extracted from the book and the numbers of shared compounds for each pair of ingredients were counted, after that a matrix table of shared compounds was developed.

The number of flavor compounds found in each ingredient were as followings: 77 in dried bean, 26 in egg, 55 in onion, 44 in chicken, 107 in apricot, 63 in celery, 43 in carrots, 79 in rice, 76 in potatoes, 31 in ground beef, 39 in leek, 13 in pumpkin, 49 in black currant, 29 in yogurt, 103 in milk, 33 in fig (Table 2).

Table 2. Matrix of shared compounds of ingredients

	Cellery	Carrot	Leek	Rice	Potato	Black currant	Bean	Yogurt	Fig	Onion	Chicken	Milk
Cellery	63	24	8	28	19	13	19	9	9	9	5	16
Carrot	24	43	4	16	14	10	15	6	5	6	4	11
Leek	8	4	39	19	13	5	13	6	11	18	5	22
Rice	28	16	19	79	31	9	38	15	18	17	18	39
Potato	19	14	13	31	76	9	20	6	9	12	14	26
Black currant	13	10	5	9	9	49	11	6	5	8	3	10
Bean	19	15	13	38	20	11	77	9	14	12	10	31
Yogurt	9	6	6	15	6	6	9	29	5	8	3	15
Fig	9	5	11	18	9	5	14	5	33	1	3	16
Onion	9	6	18	17	12	8	12	8	1	55	4	21
Chicken	5	4	5	18	14	3	10	3	3	4	44	12
Milk	16	11	22	39	26	10	31	15	16	21	12	103

On the other hand, the list of shared flavor compounds in each pair of these ingredients was formed by matching same compounds of each pair. There were 38 common flavor compounds between rice and bean, 18 common flavor components between rice and fig, 14 common flavor compounds between bean and fig, 39 common flavor compounds between milk and rice, 31 common flavor compounds between milk and bean, 16 common flavor compounds between milk and fig (Table 3). Finally, in order to formulate a new dish, rice, dried beans, milk and fig were selected as the main ingredients since they contained the highest number of shared compounds among the others. In this ingredient group that would form the new dish, 73.4% of the flavor compounds in rice were shared ones, while fig, bean, and milk, contributed 67 %, 54.5 %, 50.4 %, respectively (Table 3).

Furthermore, according to the analysis it was observed that the composition of some dishes in Marmara region were consistent with food pairing hypothesis. For example, the dish 'Milk soup with bulgur' contained chicken and milk that shared 12 flavor compounds, 'rice with apricot and raisin' and 'zerde' contained rice and apricot sharing 23 flavor compounds, celery and carrot in the dish 'Seasoned sauce meatballs' had 24 common flavor compounds, whereas leek and rice in the dish 'stuffed leek' contained 19 common compounds (Table 2). These might show that among the dishes analyzed in Marmara region most of them contained ingredients that were engaged (consistent) with food pairing hypothesis.

In the study of Ahn et al. 2011, foods in North American cuisine mostly justified by the hypothesis as well, whereas recipe data analysis results showed that East Asian dishes were not consistent with ingredient flavor pairing hypothesis. Moreover, recipes in Arab cuisine, Indian cuisine and Macedonian cuisine were analyzed in terms of flavor pairing. For example,

Tallab and Alrazgan (2016) pointed out the possible effect of applicability of food pairing method in Arab cuisine would increase innovation in various disciplines starting with food business. In another study, the contribution of each ingredient to the recipes in Macedonian cuisine was calculated and black pepper, egg, flour, sunflower oil onion, milk and garlic contributed at least 20% in the recipes. The average value of number of ingredients in the recipes was approximately 7, which is closer to the value that was calculated in our study as 8 when 12 recipes were scanned (data not shown). In the same study, the number of shared compounds of ingredient pairs dominated approximately less than 20, only a few of the pairs shared flavor compounds upper than 80 (Bogojeska et al., 2015).

Table 3. List of shared flavor compounds in selected ingredients (extracted from Burdock, 2009)

Rice and bean (38)	Rice and fig (18)	Rice and milk (39)
1-methylnaphthalene	1-octanol	1-methylnaphthalene
1-octanol	1-octen-3-ol	1-octanol
1-octen-3-ol	2-heptanone	2-heptanone
2,3,5-trimethylpyrazine	2-hexenal	2-hexenal
2,4-nonadienal	2-methoxy-4-vinylphenol	2-methylbutyraldehyde
2-methoxy-4-vinylphenol	2-octanone	2-methylpentanal
2-methylbutyraldehyde	2-pentylfuran	2-methylpyrazine
2-nonenal	6-methyl-5-hepten-2-one	2-nonanone
2-octanone	Heptyl alcohol	2-octanone
2-pentanone	Hexanal	2-tridecanone
3-methylbutyraldehyde	Hexyl alcohol	2-undecanone
3-penten-2-one	Indole	3-methylbutyraldehyde
Alpha-terpineol	n-nonanal	9,12-octadecadienoic acid plus 9,12,15-octadeca-trienoic acid
Guaiacol	n-octanal	Decanal
Hexanoic acid	Nonyl alcohol	Heptyl alcohol
Hexyl alcohol	Octanoic acid	Hexanal
Lauric acid	Palmitic acid	Hexanoic acid
Lauryl alcohol	Phenethyl alcohol	Hexyl alcohol
Linalool		Indole
Methyl disulfide		Lauric acid
Methyl sulfide		Linalool
Myristic acid		Methyl disulfide
Nerolidol		Methyl mercaptan
n-nonanal		Methyl sulfide
n-octanal		Myristic acid
Nonanoic acid		n-nonanal
Nonyl alcohol		n-octanal
n-valeraldehyde		Nonanoic acid
Octanoic acid		Nonyl alcohol
Palmitic acid		n-valeraldehyde
Phenethyl alcohol		Octanoic acid
Phenol		Phenethyl alcohol
Phenylacetaldehyde		Phenol
Propionaldehyde		Phenylacetaldehyde
Propyl alcohol		Propionaldehyde
p-vinylphenol		Propionic acid
Undecanoic acid		Pyridine
γ -nonalactone		Undecanal
		γ -nonalactone

Table 3. *cont'd* List of shared flavor compounds in selected ingredients (extracted from Burdock, 2009)

Bean and Fig (14)	Bean and Milk (31)	Fig and Milk (16)
1-octanol	1-methylnaphthalene	1-octanol
1-octen-3-ol	1-octanol	2-heptanone
2-methoxy-4-vinylphenol	2-methylbutyraldehyde	2-hexenal
2-octanone	2-octanone	2-octanone
3-hexen-1-ol	3-methylbutyraldehyde	Heptanoic acid
Heptanoic acid	Furfuryl alcohol	Heptyl alcohol
Hexyl alcohol	Heptanoic acid	Hexanal
Isobutyl alcohol	Hexanoic acid	Hexyl alcohol
n-nonanal	Hexyl alcohol	Indole
n-octanal	Isoamyl acetate	Isobutyl alcohol
Nonyl alcohol	Isobutyl alcohol	Methyl butyrate
Octanoic acid	Lauric acid	n-nonanal
Palmitic acid	Linalool	n-octanal
Phenethyl alcohol	Maltol	Nonyl alcohol
	Methyl disulfide	Octanoic acid
	Methyl sulfide	Phenethyl alcohol
	Myristic acid	
	n-nonanal	
	n-octanal	
	Nonanoic acid	
	Nonyl alcohol	
	n-valeraldehyde	
	Octanoic acid	
	Phenethyl alcohol	
	Phenol	
	Phenylacetaldehyde	
	Propionaldehyde	
	Styrene	
	Vanillin	
	γ -hexalactone	
	γ -nonalactone	

A similar research on food pairing analysis in regional recipes was conducted in India. Most of the recipes from eight regions of India contained 4-6 ingredients of range. Milk and dairy products contributed well to food pairing in the cuisine while spices in general did not contribute to the food pairing although frequency of use of spices in the recipes of eight regions was higher than the value for milk and dairy products (Jain et al., 2015). In regional basis study, co-occurrence of ingredients logarithmically decreased when the shared flavor profiles in the recipes of each region were investigated, which meant that Indian cuisine showed negative food pairing hypothesis (Jain et al., 2015).

Flavor network diagram

A flavor network diagram was constructed as a result of flavor network analysis in Marmara region dishes. Eight compounds that were common in all of four ingredients were shown in the middle of the diagram (Fig. 1). Moreover, among the 8 recipes analyzed, the number of shared compounds ranged 1 to 39, and dominated in the range of 3-19 compounds (Fig. 2).

Flavor network diagrams were used to illustrate data analysis in flavor network science, and constructed by researchers to easily visualize and evaluate the ingredient/flavor pairing in various cuisines. In the study of Ahn et al. (2011), one mode projection of a bipartite network illustrating

the nodes (ingredients and flavor compounds) and links in between them was created using the data of world cuisines concerning the categorization of food groups. In another study, a three component (recipe, ingredient and flavor compound) network regarding Indian cuisine was constructed (Jain et al., 2015). On the other hand, Traynor et al. (2013) created a network diagram to show the relations of individuals and ingredient pairs to retronasal and orthonasal characteristics of the flavor compounds that could be sensed.

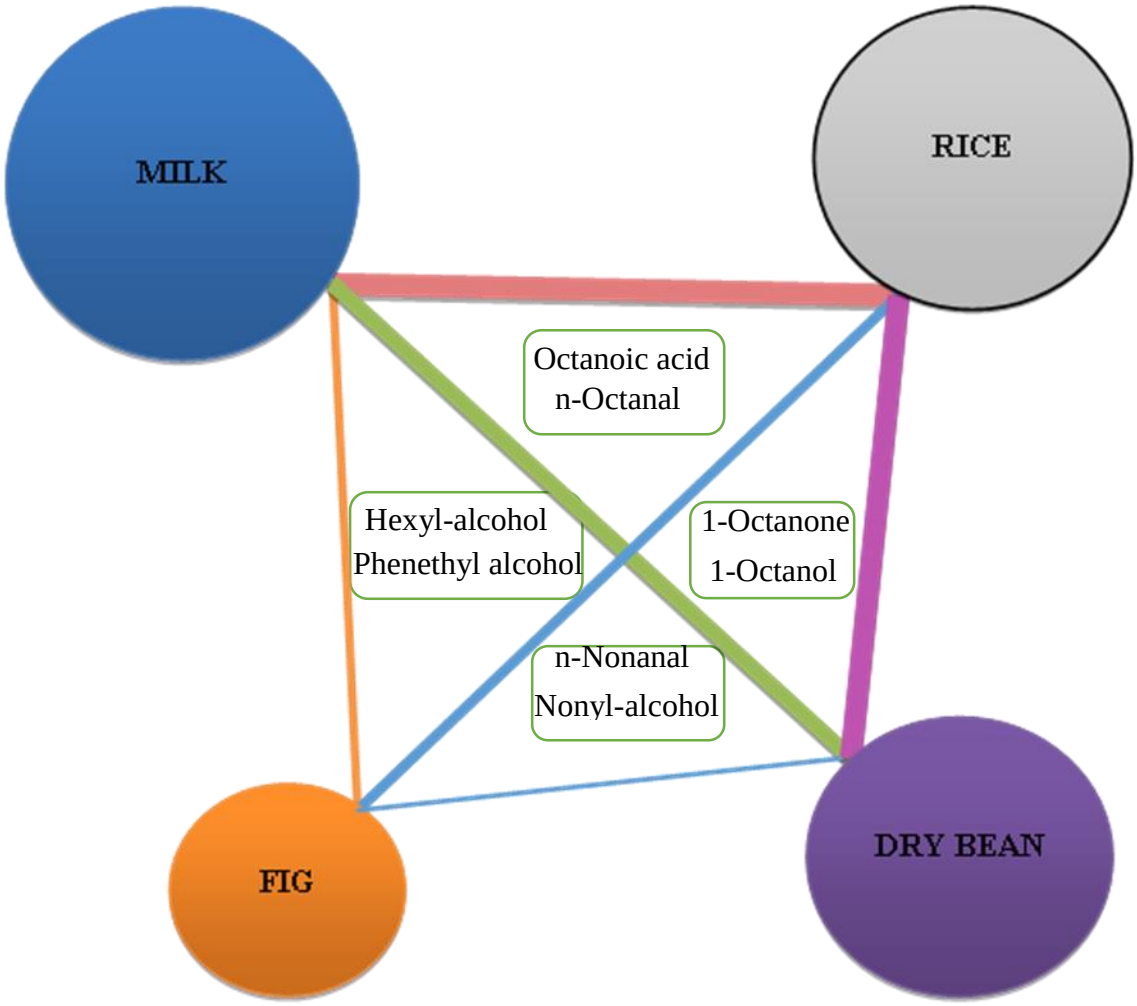

Fig. 1. Flavor network diagram. (The width of weighted links increases with increasing shared compounds. Number of shared compounds: 39 (Milk and rice); 38 (Rice and bean); 31 (Milk and bean); 18 (Milk and bean); Fig and milk (16); Fig and bean (14). The size of the circle is proportional to the number of flavor compounds the ingredient contains. The compounds with written names are the common of four ingredients).

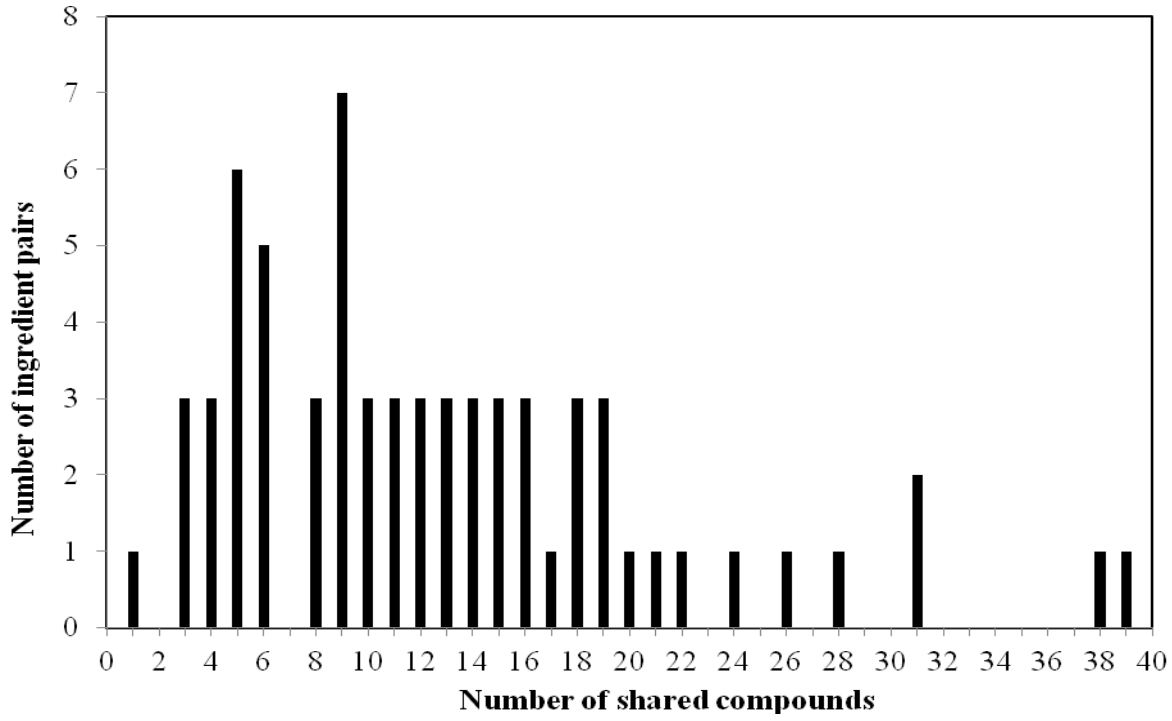

Fig. 2. Number of ingredient pairs versus number of shared compounds found in combinations of 12 ingredients.

New recipe design and sensory evaluation of consumer preference

In this study, a new dessert including main ingredients rice, dried beans, milk and fig was designed in order to justify ingredient pairing hypothesis in the recipes of Marmara region, and it was prepared as in the following method; 1 cup of rice was first boiled and after water was absorbed, a 1 L of milk was added and furthermore two ingredients were allowed to boil. After that, 1 cup of sugar was added into the mixture and boiled until it got thickened. It is apportioned for 20 servings and put into the refrigerator after they were cooled down to room temperature. For the upper part of the newly designed dessert, some dried beans were boiled and then deep fried and covered with sugar. Some figs were boiled and blended. The beans and figs were then put on the top of the dessert and put into refrigerator for a few hours. Final form of the dessert (Fig. 3) was served cold to the panel of 20 volunteer participants.

Fig. 3. New dessert developed using flavor network analysis

Nine-point hedonic scale of sensory analysis was used to evaluate the consumer preference of the new dessert formulated using the ingredients determined upon flavor network analysis. 20 volunteer students (9 women and 11 men) ranging the age of 24-30 from the department were chosen to taste the dessert and answer the questions in the questionnaire. All the participants tasted the dessert and filled out the answers in questionnaire form.

As the result of 9-point hedonic scale of sensory test, 6 out of 9 women liked the new dessert extremely, 2 out of 9 liked moderately, 1 out of 9 didn't like it. Among the men, 10 out of 11 liked the new dessert extremely, 1 disliked moderately as shown in Fig. 4. In total, 80% of the participants liked the dessert extremely. This result might confirm that the ingredients that shared high number of flavor compounds tasted well together in a recipe and new dessert formulation created using flavor network analysis was extremely preferred by the majority of the participants. On the other hand, 18 of the participants were familiar with the foods consumed in Marmara Region, 12 of those recognized a similarity between the local foods of Marmara region and the newly designed dessert. 14 participants claimed that they would order the dessert once they saw on a restaurant menu which might point out that the new dessert would be preferable by the customers in a restaurant.

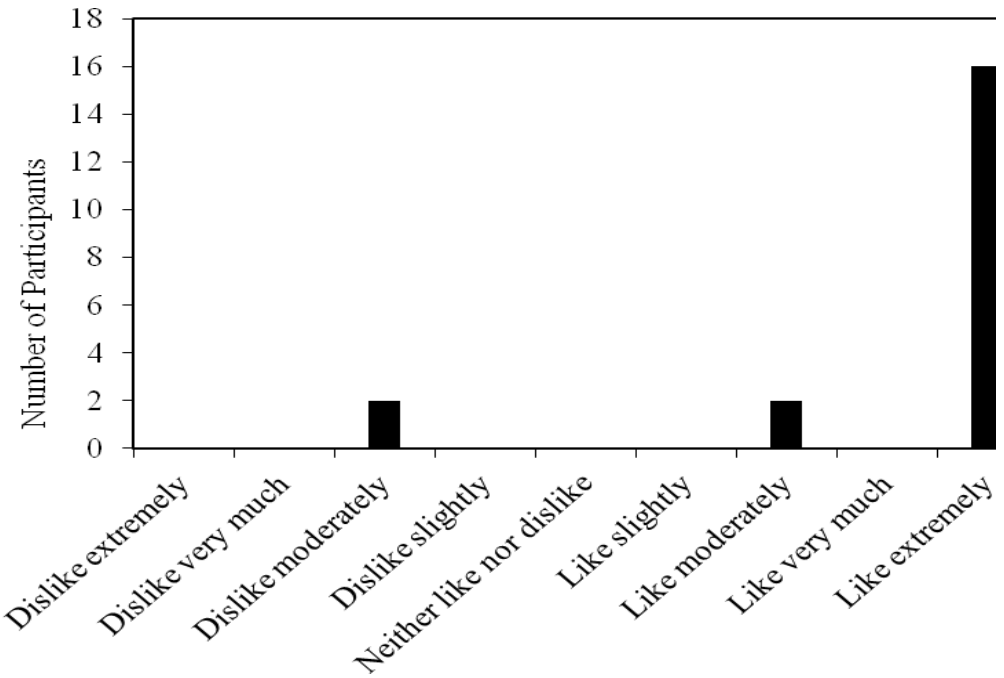

Fig. 4. Sensory evaluation of consumer preference

Data formed as a result of flavor network analysis could be used to either construct databases, or formulate new recipes with preferred taste. As mentioned above, there were a few studies conducted on data analyses of recipes from various countries, however except Henson Blumenthal's innovative dishes, only limited studies on flavor pairing network analysis were ended up with a new dish formulation (Blumenthal, 2009; Kort et al., 2010; Kutup, 2017). The ingredient lambchops and Turkish coffee sauce in a new dish shared 47 compounds, and the dish was liked by the lecturers tasted it (Kutup, 2017). In the study performed in Netherlands, seven ingredients were paired in possible combinations and put in a puree and later on a panel of 50 students scored the taste of each pair. The ingredient pairs which gained higher scores than the average score by more than 60% of students were accepted as tasting well.

However, these highly scored ingredient pairs shared lower number of flavor compounds (Kort et al., 2010). The results of this study were similar to the negative pairing of ingredients in recipes of East Asian cuisine (Ahn et al., 2011; Jain et al, 2015).

In our study, new dessert with the main ingredients, rice, bean, milk and figs was formulated, and the flavor compounds, 1-octanol, 2-octanone, hexyl alcohol, n-nonanal, n-octanal, nonyl alcohol, octanoic acid, phenethyl alcohol were found common in these main ingredients (Fig.1). Interestingly the shared characteristics of these common compounds were that they have either orange-rose like odor or fruity and citrus-honey odor, and dairy-like, waxy, fruity or citrus taste (Burdock, 2009). These results may show how the ingredients from different food groups (i.e. bean from legumes, rice from grains, milk from dairy, figs from fruits) might have common sensory characteristics when analyzed by their own, and how they could go well together in a milky, fruity, waxy sensed dessert (Fig. 3). Morover, odor and taste characteristics of eight compounds showed higher similarity focusing on fruity and citrus odor and waxy cheesy tastes, which gave us another result that citrus/fruity odors may go well together with cheesy/creamy tastes just like in the resulting dessert that we created.

According to the literature, some well-known nutrients in foods act as the precursors of aroma compounds in the food. For example, table sugar -sucrose-, added into our dessert formulation, was declared as the precursor of aroma compounds named octanal, octanoic acid, hexyl-alcohol, and octanol which were also found as the common flavor compounds of the main ingredients in our study (Reineccius, 2006). In Prescott (2015), it was mentioned that flavor perceptions might occur by odor/taste integrations in a food which might be derived from experiences leading associative learning process. As a result of this, some well known taste characteristics such as sweetness might influence the sense of odor of the same dish towards liking of the dish. Eight flavor compounds shared by four main ingredients of new dessert contained citrus-floral-fruit-fatty odor characteristics with sweet, fruity (orange, apple like) and milky, creamy taste characteristics. Therefore, these alike properties showed hat odor/taste integration could easily be achieved in the new dessert which might influence the hedonic property towards liking. Finally, our study based on the regional food data will be useful to create alternative dishes for the palate of the people who are accustomed to consume similar ingredients.

CONCLUSION

Flavor network analysis is a promising method of analyzing the data in food and gastronomy field that acts as bridge between different disciplines, such as flavor chemistry, sensory sciences, culinary sciences, and computer sciences. This study is the first research on utilization of flavor network analysis to create new dish by analyzing specifically the recipes in Marmara Region of Turkey. The results of this work suggested that ingredient pairs sharing higher number of flavor compounds led to create an alternative dish for Marmara region that was highly preferred by the majority of sensory panel participants. These results will probably raise the interests of chefs and culinary scientists who are willing to create innovative recipes using information on flavor network science and most probably look for sensory acceptance of the dishes. Besides, this methodology may find application in new food product development in the food industry as well. Furthermore, emerging area of computational gastronomy is increasingly paving the way of developing new culinary databases and digital platforms that can be shared worldwide, leading to create novel tasteful dishes. Therefore the globalization of any regional cuisine in Turkey cherishes and nourishes itself in a broader sense.

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