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The Effect of Shapes of Fruits and Vegetables on Sweet Taste Perception

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ABSTRACT

Purpose: Taste and palatability of foods are important factors for food intake, while in most cases, the first sensory contact with food may occur through sight. We aimed to examine the effects of shapes, a visual factor, on the perceived sweet taste of fruits and vegetables, thus enabling visual cues to increase consumption in the community and promote healthy nutrition.

Methods: We included 30 volunteer participants from the staff of a university in Istanbul. Angular (square and star) and oval (round) shapes are created using standard patterns in six fruits and vegetables. Participants were uninformed about tasting the same fruits and vegetables in different shapes, and the tests were repeated when they were hungry and full.

Results: At varying rates, women and men were affected by differently shaped fruits ($p<0.05$). Women were affected by the shapes of the vegetables ($p<0.05$), but no significant difference was found for men ($p>0.05$). Hunger and fullness did not cause a significant difference in the perceived sweet taste ($p>0.05$). The perceived sweet taste in both fruits and vegetables was affected in the younger participants ($p<0.05$). While there was no significance in the taste scores of overweight individuals ($p>0.05$), the participants with healthy body weights were affected by the serving shapes ($p<0.05$).

Conclusion: Consumption of fruits and vegetables, one of the main contributors to a healthy diet, might be increased with sensory cues among the community. Sex, body weight status, and age group-specified studies on larger sample sizes are recommended.

Keywords: Fruits and Vegetables; Taste Perception; Visual Appearance.

ÖZET

Amaç: Besin alımında tat ve lezzet önemli faktörlerdir; ancak çoğu durumda besinle ilgili ilk duyusal etkileşim görünüş ile kurulabilmektedir. Bu çalışma, görsel bir faktör olan şekillerin meyve ve sebzelerde algılanan tatlı tada etkisini değerlendirmek, böylece toplumda sağlıklı beslenmenin teşviki için tüketimlerinin arttırılmasında görsel ipuçlarından yararlanmayı mümkün kılmaktır.

Yöntem: Çalışmaya İstanbul'da bir üniversitenin personeli olan 30 gönüllü dahil edilmiştir. Altı farklı çeşitte meyve ve sebzede standart kalıplar kullanılarak köşeli (kare ve yıldız) ve oval (yuvarlak) şekiller oluşturulmuştur. Katılımcılara, farklı şekillerde tattıkları meyve ve sebzelerin aynı meyve ve sebze olduğu bilgisi verilmemiştir. Test, katılımcılar açken ve tokken tekrarlanmıştır.

Bulgular: Farklı şekillerde sunulan meyvelerde kadın ve erkekler farklı oranlarda şekilden etkilenmiştir ($p<0,05$). Kadınlar sebzelerin şeklinden etkilenmiş ($p<0,05$), erkeklerde ise önemli bir fark saptanamamıştır ($p>0,05$). Açlık ve tokluk, algılanan tatlı tada etki etmemiştir ($p>0,05$). Hem meyvelerde hem de sebzelerde algılanan tatlı tat, daha genç katılımcılarda şekilden etkilenmiştir ($p<0,05$). Beden kütle indeksi (BKI) değeri >25 kg/m^2 olan fazla kilolu katılımcılarda tat puanlarında anlamlı fark bulunamazken ($p>0.05$), BKI değeri 18,5-24,9 kg/m^2 olan sağlıklı vücut ağırlığına sahip bireyler sunulan şekillerden etkilenmiştir ($p<0.05$).

Sonuç: Sağlıklı bir diyetin ana bileşenlerinden olan meyve ve sebze tüketimi duyusal ipuçları kullanılarak arttırılabilir. Cinsiyet, beden ağırlığı ve yaş gruplarına özelleşmiş, büyük örneklemlerle yapılacak çalışmalara gereksinim vardır.

Anahtar Kelimeler: Meyve ve Sebzeler, Tat Algısı, Görsel Görünüm.

A healthy diet is one of the main contributors to health from prenatal to death. The main purpose of adequate and balanced nutrition is to provide the macro and micronutrients and calories required to fulfill the vital needs of the body, protect and develop health, and maximize the quality of life (1,2).

There are dietary models developed to recommend the main components of a healthy diet, including the Mediterranean diet, the DASH diet, Dietary Recommendation for Americans, and Healthy Eating Plate (MyPlate), all with recommendations for sufficient fruit and vegetable consumption (3). For example, MyPlate is designed as a plate divided into four sections, consisting of 10% fruits and 40% vegetables (2,4). Similarly, the World Health Organization recommends the daily consumption of at least 400 g of fruits and vegetables (1). As fruits and vegetables are rich in fiber, vitamins, and minerals, adequate consumption of fruits and vegetables may reduce the risk of several chronic diseases, including some types of cancer, cardiovascular diseases, and gastrointestinal system diseases; strengthen the immune system; prevent the development of inflammatory diseases (5). According to the Turkey Nutrition and Health Survey (TNHS) conducted by the Turkish Ministry of Health, the rate of those aged 15 and over in Turkey who never consume green leafy vegetables is 4.5%, the rate of those who never consume other fresh vegetables is 12.3%, the rate of those who never consume citrus fruits 4.1%, the rate of those who do not consume other fresh fruits is 3.7% (6).

Food preferences form the basis of individuals' balanced and adequate nutrition. Food preferences of individuals develop depending on many factors, including cognitive, sensory, and environmental factors (7). Sensory factors affecting food preferences are taste, appearance, smell, texture, temperature, and flavor. Although the taste and flavor of foods are the most essential characteristics of individuals, the first contact with food takes place by sight (8). The shape of the food, portion size, color, and volume are the first impressions of the food, and this first impression is suggested to affect the food preferences of the individuals and the portion consumed (9). It is hypothesized that the round shape of the foods to be consumed may create a preliminary signal that the person will perceive a sweet taste at first sight and that they will perceive more bitter and sour tastes if they are in angular shapes such as squares. Thus, visual cues are suggested to increase the consumption of vegetables and fruits in adults. The aim of this study is to determine the effects of the visual appearance of fruits and vegetables on sweet taste and enable interventions to increase the consumption of vegetables and fruits.

Materials and Methods

Participants and Data Collection

This study was conducted in June 2021 with 30 voluntary individuals among the staff of a Private University in Istanbul, Türkiye. The ages of the participants ranged from 26 to 61 years. Inclusion criteria were being between 18 and 65 years of age, not having trauma after intraoral surgery that may affect the sense of taste, not having neuropathy, not using Anti-Parkinson Drugs, not smoking, not having kidney failure, not having a diagnosis of malnutrition, not receiving radiotherapy or chemotherapy treatment.

The data were collected via a face-to-face questionnaire. To make the shapes of fruits and vegetables identical, the same square, round, and star cookie cutters were used in the cutting process. Fruits and vegetables were chosen seasonally: apple, melon, and watermelon for fruits; cucumber, zucchini, and pepper for vegetables. Pieces taken from the same fruit and vegetables were given to the same participant on numbered plates when hungry (at least eight hours after the last meal) in a laboratory environment (food preparation laboratory of the Department of Nutrition and Dietetics). After tasting and scoring each fruit and vegetable, the participants consumed a variety of traditional foods prepared and served by the researchers until they felt entirely full, and the test was repeated immediately afterward. The participants were asked to drink water between the taste tests until there was no distinct taste on the palate. A Likert scale was used for the different shapes of each fruit in each section, with a score of 1 to 5 for the sweetness (1 - very tasteless, 2 - tasteless, 3 - medium, 4 - sweet, 5 - very sweet). Additionally, the sex, age, body weight, and height of the participants were collected. Body mass index (BMI) was calculated as weight in kilograms divided by the square of the height in meters (kg/m^2) (10).

Statistical Analysis

Analyzes were performed using the SPSS 25.0 statistical package program. Non-parametric tests were used as the data showed a non-normal distribution compared to the Shapiro-Wilk normality test. Kruskal Wallis test was performed to determine whether different shapes affect taste

perception in different vegetables and fruits in the whole population. Then, the Friedman test was performed separately according to sex, age, and BMI. The confidence interval was determined as 95%, a p-value <0.05 considered statistically significant.

Results

73.3% (n=22) of the participants were women, and 26.7% were men; 46.7% were between the ages of 26 and 36 years (grouped as young adults), and 46.7% were between 36 and 61 years. There was no significant difference in the scores for the sweet taste of apple and melon in different shapes regarding hunger or fullness (p>0.05). However, there was a statistically significant difference between the scores for the sweet taste of watermelon. Star-shaped watermelon was sweeter when the participants were hungry (p<0.05). There was no significant difference between the scores given for vegetables in different shapes when compared regarding hunger and fullness (p>0.05) (Table 1).

Table 1: Hunger - Full General Test Fruits and Vegetables

		Hungry	Full	
Fruits and Vegetables	**Shape**	Mean	Mean	p
Apple	Square	1.97	2.00	0.868
	Round	2.17	1.98	0.251
	Star	1.87	1.02	1.000
Melon	Square	2.20	2.07	0.723
	Round	1.93	1.90	0.543
	Star	1.87	2.03	0.125
Watermelon	Square	1.93	2.12	0.947
	Round	1.80	1.93	0.724
	Star	2.27	1.95	0.031*
Cucumber	Square	2.20	1.97	0.294
	Round	1.88	1.92	0.701
	Star	1.92	2.12	0.400
Zucchini	Square	2.02	1.97	0.804
	Round	2.17	2.05	0.685
	Star	1.82	1.98	0.414
Pepper	Square	2.12	2.13	0.707
	Round	1.88	1.95	0.660
	Star	2.00	1.92	0.796

*Wilcoxon test; *p<0.05*

When the scores for differently shaped fruits were analyzed regarding the age of the participants, there was a significant difference between hunger and fullness measurements in both young adult and adult groups (p<0.05). According to the scores given for vegetables by two age groups, there was a statistically significant difference in the sweetness level measurements of cucumber, zucchini, and peppers with different shapes in different shapes (p<0.05). However, there was no significant difference in the scores given for the sweet taste of different vegetables in different shapes when the participants were hungry or full for adults (36-61 years old) (p>0.05) (Table 2).

Table 2. The Effect of Shapes on Fruits and Vegetables in Different Age Groups

		Age Groups							
		Young Adult				Adult			
		Hungry		Full		Hungry		Full	
Fruits and Vegetables	**Shape**	Mean	p	Mean	p	Mean	p	Mean	p
Apple	Square	3.04	<0.001*	2.86	<0.001*	2.96	<0.001*	3.11	<0.001*
	Round	3.07		3.18		3.07		2.71	
	Star	2.89		2.96		2.71		2.96	
Melon	Square	3.21	<0.001*	3.25	<0.001*	3.18	<0.001*	2.89	<0.001*
	Round	3		2.75		2.64		3.04	
	Star	2.75		2.96		2.96		2.93	
Watermelon	Square	2.93	<0.001*	3.14	<0.001*	2.96	<0.001*	2.96	0.017**
	Round	2.86		2.86		2.46		2.79	
	Star	3.14		2.89		2.43		2.54	
Cucumber	Square	2.79	0.004**	2.64	0.008**	3.04	0.098	2.39	0.649
	Round	2.61		2.75		2.21		2.29	
	Star	2.82		2.82		2.18		2.71	
Zucchini	Square	2.89	<0.001*	2.79	<0.001*	2.36	0.773	2.29	0.698
	Round	3.29		3		2.36		2.46	
	Star	2.36		2.82		2.64		2.5	
Pepper	Square	3	0.001**	3.14	<0.001*	2.64	0.355	2.5	0.998
	Round	2.75		2.79		2.11		2.54	
	Star	2.68		2.64		2.75		2.46	

*Freidman test; *p<0.01; **p<0.05*

When the scores were evaluated regarding the BMI of the participants, there was a significant difference in the scores of the sweet taste of the differently shaped fruits when the participants were hungry and full (p<0.01). In participants with normal body weight, there was a significant difference in sweetness scores between the repeated measurements of differently shaped cucumber, zucchini, and pepper in hunger and fullness (p<0.05), while there was no significant difference in overweight individuals (p>0.05) (Table 3).

Table 3: The Effect of Shapes on Fruits and Vegetables in Normal Weight and Overweight Individuals

Fruits and Vegetables	Shape	BMI							
		Normal body weight				Overweight			
		Hungry		Full		Hungry		Full	
		Mean	p	Mean	p	Mean	p	Mean	p
Apple	Square	3.08		3.27		2.90		2.70	
	Round	3.18	<0.001*	3.00	<0.001*	3.07	<0.001*	3.00	<0.001*
	Star	2.68		2.68		2.80		3.17	
Melon	Square	3.23		3.23		3.07		2.90	
	Round	2.95	<0.001*	2.95	<0.001*	2.83	<0.001*	2.83	<0.001*
	Star	2.82		2.77		2.83		3.03	
Watermelon	Square	2.95		3.32		2.90		2.77	
	Round	2.55	<0.001*	2.82	<0.001*	2.70	<0.001*	2.87	0.001**
	Star	3.45		2.55		3.10		2.93	
Cucumber	Square	3.09		2.64		2.83		2.17	
	Round	2.59	0.001*	2.68	0.035*	2.07	0.15	2.37	0.166
	Star	2.59		2.82		2.30		2.57	
Zucchini	Square	2.95		2.82		2.40		2.20	
	Round	2.91	0.002*	2.68	0.017*	2.80	0.359	2.83	0.345
	Star	2.68		2.68		2.13		2.53	
Pepper	Square	2.86		2.68		2.77		2.80	
	Round	2.55	0.009*	2.86	0.011*	2.33	0.686	2.50	0.504
	Star	2.95		2.73		2.43		2.33	

*Freidman test; *p<0.01; since 1 of the participants was found to be below normal body mass index and 1 of them was obese, they were not included in the statistical comparative analysis. BMI; Body Mass Index*

There was a significant difference in the scores for the sweet taste of fruits in both men and women tested as hungry and full (p<0.01). For vegetables, there was a significant difference between the scores for cucumber, zucchini, and pepper in different ways in women (p<0.01). However, there was no significant difference in men (p>0.05) (Table 4).

Table 4: The Effect of Shapes on Fruits and Vegetables in Different Sex

Fruits and Vegetables	Shape	Sex							
		Women				Men			
		Hungry		Full		Hungry		Full	
		Mean	p	Mean	p	Mean	p	Mean	p
Apple	Square	2.91		3.02		3.13		2.88	
	Round	3.16	<0.001*	3.02	<0.001*	3.13	<0.001*	2.94	0.002**
	Star	2.91		2.93		2.69		3.06	
Melon	Square	3.20		3.07		3.13		3.00	
	Round	3.00	<0.001*	2.86	<0.001*	2.63	0.012	2.81	0.001**
	Star	2.80		3.02		2.88		3.00	
Watermelon	Square	2.84		3.16		3.13		2.75	
	Round	2.80	<0.001*	2.75	<0.001*	2.69	0.001**	3.13	<0.001*
	Star	3.32		2.84		3.06		3.00	
Cucumber	Square	3.02		2.75		2.56		2.25	
	Round	2.66	<0.001*	2.73	<0.001*	2.19	0.682	2.06	0.172
	Star	2.55		2.89		2.81		2.75	
Zucchini	Square	2.89		2.77		2.25		2.50	
	Round	3.09	<0.001*	2.93	<0.001*	2.38	0.591	2.31	0.921
	Star	2.57		2.77		2.44		2.56	
Pepper	Square	3.00		2.95		2.56		2.88	
	Round	2.61	<0.001*	2.91	<0.001*	2.44	0.958	2.13	0.315
	Star	2.87		2.66		2.63		2.75	

*Freidman test; *p<0.01; **p<0.05*

Discussion

Nutrition is a psychological and physiological factor for humans. The individual's first relationship with food is known as the cephalic phase. It starts with thinking, seeing, and sniffing (11-13). Various sensory cues such as appearance, taste, smell, texture, temperature, and flavor are effective at the individual's food intake level (14). Although the taste of foods is an important factor that regulates food intake, in most cases, the first sensory contact with food occurs through seeing (15). Few studies examine the effects of food's appearance during service on food acceptance and consumption.

It was thought that the round shape of the foods to be consumed could create a preliminary signal that the person would perceive a sweet taste at first sight and that they would perceive more bitter and sour tastes with angular shapes such as squares (14). In previous studies, different results were obtained regarding the effect of food shape, and each study was conducted with different groups and foods. For example, according to a survey conducted with volunteers between the ages of 20-50, it is suggested that the round shape of the foods to be consumed may create a preliminary signal that the person will perceive a sweet taste at first sight and that they will perceive more bitter and sour tastes if they are in square, angular shapes (14). In another study evaluating the relationship between basic tastes and visual cues, in an online survey with 131 eligible participants, participants were asked to rate their sweet, sour, bitter, and salty tastes on a Likert scale by showing food animations in different colors and shapes. The sweet taste and red color were paired with a round shape, while the sour and green colors matched (15). Wang et al. used different, identical dark chocolates and asked the participants to enumerate the differences between sweetness, bitterness, and creamy feel. In addition, the expectations for each chocolate were asked to be rated before tasting, and the post-taste and pre-taste expectations were compared. As a result, they concluded that the expectation and post-tasting thought were parallel, and the shape of the chocolate significantly affected the tasting. The round ones were less sweet, more bitter, and less creamy, and the square ones were sweeter and creamier than the round ones (16).

According to the study of Slavin et al., hunger and feeling of fullness affect food preferences (17), and we found that individuals were more sensitive to sweet taste perception in the case of hunger as supported by Khobragade et al. (18). To understand the effect of age groups on the perception of sweet taste in different ways, the participants were divided into two groups. Young adults aged 26 to 35 years were classified as adults aged 36 to 61 years. There was no statistically significant difference in the sweet taste level of different presentations of vegetables in both hunger and fullness states in adults. In young adults, different shapes stood out in different vegetables and fruits. This may be due to a decrease in taste sensitivity with age. In a study published by Fukunaga et al. in 2005, the change in the threshold and capacity of sweet, salty, sour, and bitter taste perceptions was investigated with 30 healthy young and adult volunteers (19). Similar to our results, it was observed that especially sweet taste perception was significantly lower in older adults. The reason for this is suggested to be the decrease in sweet taste sensitivity with advancing age, as the effects of physiological aging on the perception of taste are represented by the alterations of taste cells and the reduction of salivary production (20). Even our sample did not involve older people. The perception of salty, bitter, and sour tastes did not change as significantly as the sweet taste. Cucumber star-shaped, squash round-shaped, and pepper square-shaped in young adults were recorded as sweeter. While there was no difference in vegetables in adults, a difference was observed in fruits. This may be because vegetables have a lower sweet taste than fruits. This difference may have been seen because the sweet taste level of the fruits was more dominant. Apples were found to be sweeter in round shape in both adults and young adults when hungry and full, while the shapes of melon and watermelon varied. Young adults found square melon sweeter when hungry and full, older adults found square melon sweeter when hungry, and round melon when full. Young adults found the watermelon sweeter when starved and square when full, while adults found the square watermelon sweeter. When the fruits in every age group are examined in general, it is seen that the square shape comes to the fore. Especially for melons and watermelons, the square shape of the fruit with a softer structure caused the fruit to be perceived as sweeter.

Additionally, we evaluated the variation of the results according to body weight. Overweight participants did not report a difference in sweet taste levels in the different shapes of vegetables, as it is suggested that there might be a negative correlation between the increase in BMI and sweet taste sensitivity (21).

The sweet taste level was also affected by different shapes when analyzed regarding sex. Various results have been

obtained for different fruit shapes in both men and women. However, when vegetables were considered, there was a difference in women, while there was no difference in men. The main reason men do not differ in the sweet taste of different shapes of vegetables may be the resistance of men participants to vegetable consumption. It has been suggested that taste sensitivity is more prone to deteriorate in men than in women, which may be due not only to genetic factors but also to factors such as lifestyle-related diseases, medications for the diseases, and smoking and drinking habits (22). In the laboratory environment, men participants did not want even to taste the vegetables and had to taste them to complete the study. The dislike they felt towards vegetables may have also affected their perceived taste. Looking at the statistics, it is seen that men already give low scores to every shape of vegetable. In public health nutrition, the vegetable consumption of men in Turkey should be investigated, and this issue should be given importance in future studies. Although a recent cross-sectional study from Turkey has reported the quantities of vegetable and fruit intake were higher in men (23), regarding the results of TNHS men of the age group of 19-64 years, the frequency of those who never consumed green leafy vegetables was 5.6%, the frequency of those who consumed them every day was 21.6%, and the frequency of those who never consumed other fresh vegetables (leek, cabbage) was 19.4%, the frequency of those who consumed them every day was 1.7% (6). This prejudice of men against vegetables should be known when intervention in the consumption of vegetables and fruits in society. In women, more significant differences were seen in the fasting state, where taste sensitivity was higher for vegetables except cucumber. Cucumbers and pepper were perceived as sweeter in square shape and zucchini in round shape when hungry. This may be because cucumbers and peppers are more crunchy, firm, and chewy, while zucchini is softer. Only cucumbers gave significant results in fullness among women. Star-shaped was perceived as sweeter. In this case, it may be suggested that cucumber is perceived as sweeter in angular shapes when hungry or full, but soft foods such as zucchini are perceived as sweeter in round shapes, and women are more sensitive to vegetable taste than men.

Conclusion

Further, participants could be asked about their expectation of sweet taste when they saw different shapes of vegetables and fruits, and the result could be compared with the expectation. In this case, while the pre-tasting expectation was lacking in our study, the post-tasting evaluation was missing in most similar studies. This may be considered in future studies. Moreover, sex, body weight status, and age group-specified studies on larger sample sizes are strongly recommended.

Declarations

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Conflicts of İnterest/Competing İnterests

The authors have no conflicts of interest to disclose.

Ethics Approval

This study was performed with the ethical approval of the Research Ethics Committee of Yeditepe University with decision number 1394 dated 03/03/2021, project number 2080 (could be provided upon request). The authors declare that all experiments on human subjects were conducted under the Declaration of Helsinki and that all procedures were carried out with the subjects' adequate understanding and written consent.

Availability of Data and Material

The authors can provide the original data.

Authors' Contributions

The first author conceived and designed the analysis, collected the data, performed the data analysis, and wrote the paper. The second author conceived and designed the analysis and wrote the paper.

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