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Color and Its Effect on Dietitians' Food Choices: Insights from Tomato Juice Evaluation

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Abstract: Color plays a significant role in consumer decisions about food products, influencing preferences and choices and eliciting positive or negative associations. This study aimed to investigate the impact of color on dietitian food preferences, using selected tomato juices as an example. This study was conducted in two stages. In the first stage, the color of the tomato juices was evaluated using a Tri-Color SF80 spectrophotometer. In the second stage, the serialization method performed sensory analysis among dietitians. Results showed that dietitians pay special attention to the color of food products. Spectrophotometric analysis indicated that not all tested pairs of juices had color differences noticeable to an inexperienced observer. There was no clear correlation between the specific color parameters and the choices made by dietitians. These findings suggest that while color is an important factor in consumer preferences, it is not the sole determinant, highlighting the complexity of consumer decision-making processes and providing valuable insights for product marketing strategies.

Keywords: color measurement; cielab system; sensory analysis; purchase intention; dietitians' preferences; taste; consumer behavior

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1. Introduction

The tomato is one of the most popular vegetables consumed by humans. We consume both raw tomatoes and preparations such as soups, purees, sauces, and juices. Tomato juices available on the market vary in texture, color, taste, and smell. Understanding how color influences dietitians' preferences can help design products that better meet this professional group's expectations, which strongly influences dietary recommendations for the broader population. One of the primary criteria for product selection is its color, so the use of spectrophotometric methods for their evaluation is growing.

Tomatoes are of great nutritional importance due to their health-promoting properties and culinary qualities. They are among the low-calorie products (14.2 kcal/100 g) with a high content of potassium, vitamins, micronutrients, and macronutrients. Among the nutrients, lycopene deserves special attention. It belongs to the group of antioxidant compounds and is a carotenoid—a pigment that determines yellow, orange, or red color [1,2]. Depending on the variety, the lycopene content of the tomato fruit ranges from 0.9 to 5.0 mg/100 g dry weight. In the human diet, 80% of lycopene comes from tomatoes and their processed products. Often, the processing of fruits and vegetables involves significant nutritional losses [1]. Lycopene is one of the exceptions, as processing the tomato increases its bioavailability. Most lycopene is found in processed tomato products, especially juices obtained from concentrated juice, concentrates, ketchup, sauces, and pastes [3].

Tomato juice is extensively consumed for a multitude of purposes, contributing to its status as a highly versatile beverage within diverse dietary regimes. It is frequently ingested as a refreshing beverage, attributed to its robust, savory flavor profile. Additionally, tomato juice serves as a convenient meal or snack substitute, owing to its nutrient-dense composition and satiating properties. Its widespread utilization as a fundamental ingredient in cocktails underscores its significance in culinary practices [4,5].

Moreover, tomato juice is rich in essential vitamins, minerals, and potent antioxidants, notably lycopene, which confers numerous health benefits. This confluence of culinary flexibility and nutritional value highlights tomato juice as an indispensable component in multiple households and dietary patterns, reinforcing its role in promoting overall health and well-being [3,4].

Dietitians' preferences related to juice color are based on their knowledge that product color is related to nutrient content and can affect sensory senses, thus influencing product consumption. Assessing the consumer preferences of dietitians is very important because dietitians, as educators of their patients, influence and modify their dietary choices. Why does a dietitian prefer specific brands of juice?

The sensory senses of taste, smell, texture, and color play an important role in choosing a particular product. In addition to price, brand, or type of packaging, the primary determinant in choosing a product is the sense of sight. It provides information about the size, shape, or color of the product, and this can indicate its freshness and attractiveness [6]. The appearance of food products in terms of color, in particular, greatly influences the perception of food quality. Color can be correlated with various quality attributes; its changes allow their immediate control and verification [7]. Integrating consumer preferences with CIELAB's color assessment enables effective nutrition communication and keeps the sensory quality of food products at a high level [8].

Color is of particular importance in the selection of food products; it is what has a significant impact on dietitians' preferences and dietary choices. A specific color of a product evokes a dietitian's positive or negative associations.

The CIELAB color space is widely used in the color control and management industry due to its accurate representation of human color perception and standardization [9–11]. It measures color based on three coordinates: L* (lightness), a* (red–green), and b* (blue–yellow), facilitating global comparability of measurements [11,12]. This method is particularly useful in scientific research on fruit juice color, allowing for the monitoring of color changes over time and providing intuitive, easily interpretable results. By considering human color perception, CIELAB is an ideal tool for the sensory analysis of food products [9,13,14].

To optimize sales, sensory analysis techniques are used to show potential consumers' preferences for the product under study [15,16]. One of the most important food attributes evaluated by dietitians first is color, which indicates the quality of products. Understanding dietitians' preferences can help create products that are not only healthy but also visually appealing, which can increase their effectiveness in promoting healthy eating.

From a dietitian's perspective, the "attractiveness" of a food product is a multifaceted concept that encompasses both sensory and health aspects. Studies suggest that less saturated packaging colors are perceived as indicators of healthier food [17]. Color saturation impacts the perception of a product's healthiness, with less saturated colors strongly associated with perceived health benefits, while more saturated colors are linked to sensory appeal [18].

Dietitians, as nutrition experts, focus on product characteristics that indicate nutritional value and health benefits. Therefore, packaging for health-conscious consumers should incorporate colors and materials that communicate the naturalness and healthiness of the product [18]. Packaging made from natural materials, such as paper, can enhance the perceived healthiness and naturalness of the product, which is crucial for dietitians recommending healthy food choices [19].

Additionally, dietitians may be skeptical of health labels if they are not supported by an appropriate sensory presentation. Research indicates that a multisensory experience, including the ability to touch and taste the product, can reduce skepticism toward health labels and improve product evaluation [18]. Consequently, product packaging should be designed to harmonize all sensory and informational cues to effectively convey the health attributes of the product [17].

In the context of dietitians' perception of attractiveness, it is important that the product not only meets health standards but is also presented in a way that is perceived as authentic and consistent with the product's natural origin. Such an approach can increase the product's acceptance by dietitians and their recommendations to a broader population of consumers [17–19].

The purpose of this study was to analyze in detail the dietitians' dietary preferences for the color of tomato juices. Specific objectives included (1) measuring the color of tomato juices using spectrophotometry in the CIELAB color system, (2) assessing the visual appeal and taste of these juices using a ranking method, and (3) examining the correlation between dietitians' preferences and the color characteristics measured in the CIELAB system. The analysis was aimed at understanding how color perception influences the evaluation of food products by dietary professionals, which may contribute to a better understanding of the influence of sensory characteristics on dietary choices.

One of the key innovations of this study is the application of the CIELAB color space in evaluating the color of tomato juices. This method offers precise and standardized measurements, enabling an accurate comparison of color characteristics across different samples. By correlating these measurements with dietitians' preferences, this study highlights the importance of color as a determinant of product appeal and perceived nutritional value.

The significance of this research lies in its potential to inform the development of food products that are not only nutritionally beneficial but also visually appealing. Understanding dietitians' preferences can help manufacturers design products that meet the aesthetic and sensory expectations of this influential group, thereby enhancing their effectiveness in promoting healthy eating habits. Moreover, the study's findings can be used to optimize marketing strategies, ensuring that the visual presentation of food products aligns with consumer preferences and drives healthier dietary choices.

In preparation for the study, the following research hypothesis was established: "There is a significant relationship between the intensity and hue of tomato juice color and its preference by dietitians, with brighter and more intense colors being associated with higher sensory appeal and perceived nutritional value."

2. Materials and Methods

2.1. Study Design

The survey was conducted in December 2022. This study included five pasteurized tomato juices (100% juice) from different producers (sample designations: PD, HT, FT, SV, and TB) available on the Polish market. The juices that qualified for the study differed in their method of preparation and price (Table 1).

Table 1. Characteristics of the tested juices.

Name Juice	Sample Code	Composition and Method of Production	Price	City, Country
PD	981	Tomato juice from fresh tomatoes, salt, and water	8.59 zł/l	Krobia, Poland
HT	663	Tomato juice is 100% concentrated tomato juice and salt	3.69 zł/l	Warsaw, Poland
FT	438	Tomato juice from concentrated tomato juice, tomato puree, and salt	3.19 zł/l	Warsaw, Poland
SV	154	Tomato juice from concentrated tomato juice and salt	1.99 zł/l	Oborniki, Poland
TB	143	Tomato juice from concentrated tomato juice, tomato juice, and salt	3.79 zł/l	Tymbark, Poland

This study was carried out in a sensory analysis laboratory designed according to the PN-EN ISO 8589:2010 standard [20]. The Declaration of Helsinki of the World Medical Association guided the conduct of this study. The study protocol (KNW-0022/KB1/73/I/16) was reviewed by the Bioethics Committee of the Silesian Medical University in Katowice and was approved. Each person participating in the study gave informed consent to participate in the study and was informed about the anonymity of the results.

2.2. Color Measurements

Color measurements were conducted using a Tri-Color SF80 spectrophotometer (Narama; Poland), calibrated to the L* 90.08, a* −0.74, and b* 0.70 standards within the SCI3 measurement geometry. A D654 light source and a 10° observation angle were employed. Additionally, 30 mL of a specific tomato juice was poured into a cuvette for the measurement process, and 15 separate measurements were taken. The arithmetic mean of these measurements was then calculated. Before measuring the color of juice from another manufacturer, the cuvette was rinsed with running water and dried thoroughly.

In addition, after obtaining the CIELAB parameters, ΔE was calculated based on the following formula:

$$\Delta E = \sqrt{(L_2 - L_1)^2 + (a_2 - a_1)^2 + (b_2 - b_2)^2}$$

L_1 and L_2 are the lightness values for the first and second samples.
a_1 and a_2 are the values of the a* (red–green) axis for both samples.
b_1 and b_2 are the values of the b* (yellow–blue) axis for both samples.

2.3. Sensory Analysis

Sensory analysis was conducted among 60 female dietetics students of the Silesian Medical University in Katowice in the sensory analysis laboratory. The age of the respondents was 24 ± 5.34 years. All the students were actively working as dietitians (the students had completed their first degree, qualifying them to practice as dietitians). This study was quantitative and conducted using a proprietary questionnaire.

The sensory analysis was carried out following ISO 8587:2006 standards [21]. Five samples of tomato juice were prepared, each marked with a random three-digit code to ensure impartiality. The samples were presented in identical, transparent plastic cups, each containing 30 mL of juice. The juices were served at a consistent temperature of 8 °C, which is typical for chilled juice consumption.

The samples were presented in a randomized order to avoid any bias related to the sequence of tastings. Each participant was given a short break with water provided to cleanse their palate between tasting different samples, ensuring that the flavor of one sample did not affect the perception of the subsequent ones.

The sensory tests took place in a dedicated sensory analysis laboratory equipped with individual booths to minimize distractions and ensure a controlled environment. Each booth was adequately lit, and the ambient temperature was maintained at 22 °C.

In the study, participants evaluated juice samples, with each sample being assessed in two stages: visual and sensory. In the first stage of visual evaluation, participants rated the color of the juice on a scale from 1 to 5, where 1 indicated the most acceptable color and 5 the least acceptable. The color evaluation was conducted systematically under uniform lighting conditions to ensure the consistency and reliability of the results.

Subsequently, following the visual assessment, participants proceeded to the second stage, which involved the sensory evaluation of the samples based on taste. During the tasting, participants were able to see the color of the juice. This stage also employed a scale from 1 to 5, where 1 denoted the most acceptable taste and 5 the least acceptable.

A crucial element of the study was that the taste evaluation immediately followed the color evaluation, allowing participants to directly compare their visual impressions with their sensory experiences. This arrangement aimed to understand how the visual characteristics of the juice, such as color, influence the perception of its taste.

2.4. Statistical Analysis

The results of the color measurements were compiled using Color QC (2023) and Microsoft Office Excel 2019, and statistical calculations were performed in Statistica 13.3 (StatSoft 2017).

The data presented in percentage format referred to the distribution of ratings given by the participants for the sensory attributes of the tomato juice samples, specifically their color and taste. These percentages represented how frequently each rating (from 1 to 5) was assigned to the juice samples by the participants.

Central tendencies of these ratings were described using the arithmetic mean with standard deviation to summarize the average rating and variability, respectively. The median with an interquartile range was also provided to describe the central value and the spread of the middle 50% of the ratings.

The Shapiro–Wilk test was employed to verify the normality of the data distribution, ensuring that the appropriate statistical tests could be selected based on whether the data followed a normal distribution. A nonparametric analysis of variance (ANOVA) was used to perform a statistical analysis of the sensory test results. Relationships between color and taste ratings were analyzed using Spearman's rank correlation coefficient and the corresponding significance test.

The criterion for statistical significance was $p < 0.05$.

3. Results

3.1. Instrumental Color Analysis of Tomato Juice by Spectrophotometric Method in CIELAB Color System

In the study, measurements of lightness and color parameters a* and b* were taken for various brands of tomato juice. FT tomato juice exhibited an L* lightness value ranging from 30.08 to 30.12, an a* value from 9.9 to 9.94, and a b* value from 6.33 to 6.39. HT tomato juice showed an L* lightness value from 29.65 to 29.71, an a* value from 9.5 to 9.55, and a b* value from 5.5 to 5.54. PD tomato juice had an L* lightness value from 32.54 to 32.63, an a* value from 9.77 to 9.80, and a b* value from 8.06 to 8.16. SV tomato juice recorded an L* lightness value from 31.78 to 31.82, an a* value from 10.98 to 11.02, and a b* value from 7.28 to 7.33. Finally, TB tomato juice demonstrated an L* lightness value from 32.07 to 32.10, an a* value from 10.79 to 10.82, and a b* value from 8.64 to 8.70.

Comparing the averages of color measurements, PD tomato juice had the highest L* value, and HT juice had the lowest. In contrast, the highest a* value was obtained for SV juice and the lowest for HF juice. The parameter b* highest was for TB juice, and HF juice had the lowest value (Table 2).

Table 2. Comparison of average values of color measurements.

Juice Name	L* (X ± SD)	a* (X ± SD)	b* (X ± SD)
HT	29.67 ± 0.02	9.53 ± 0.01	5.52 ± 0.01
PD	32.59 ± 0.02	9.79 ± 0.01	8.09 ± 0.01
SV	31.80 ± 0.01	10.99 ± 0.01	7.31 ± 0.01
TB	32.08 ± 0.01	10.80 ± 0.01	8.67 ± 0.02
FT	30.1 ± 0.01	9.92 ± 0.01	6.36 ± 0.02
p-value	0.043 *	0.121	0.021 *

X= average; SD = standard deviation; * = $p < 0.05$; L* = lightness; a* = green–red tones; b* = blue–yellow tones.

The average values of the juice color measurements are shown in the chromaticity charts (Figure 1).

The parameter L*, which determines the lightness of the samples, ranged from 29.67 to 32.59. Statistical analysis of the results showed that all samples differed significantly in lightness. PD juice had the highest lightness (L = 32.59), while HT juice was the darkest. The values taken by the parameter a* were indicative of the red color of the samples. SV juice was characterized by the most intense red color with relatively low lightness; the values of these measurements were a* = 10.99 and b* = 7.31, respectively. HT juice was characterized by the weakest red color, a* = 9.53. Positive values of the parameter b* determined the yellow color of the tested sample. The tested tomato juices ranged from b* = 5.52 to 8.67. TB juice had the highest values of the parameter b*, indicating the most intense yellow color, while HT juice was the least yellow.

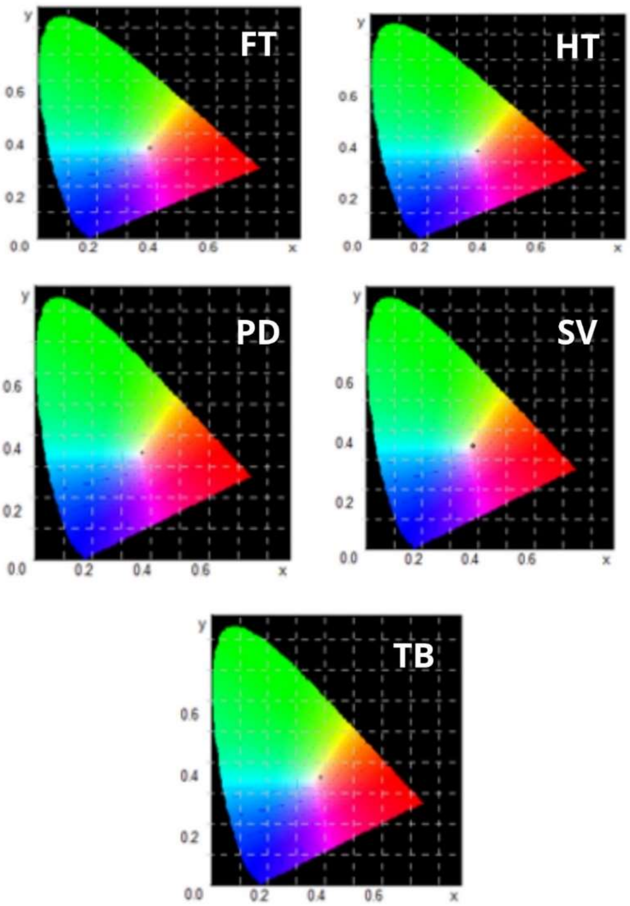

Figure 1. Chromaticity charts showing juice color measurement values.

There were color differences between the juices analyzed, documented by colorimetric examination. A clear color difference (3.5 < ΔE < 5) was recorded between TB and HT juice. Color differences discernible even by an inexperienced observer (2 < ΔE < 3.5) occur between HT juice and PD, SV, and TB juices and between FT and the others. Differences between PD−SV, PD−TB, and HT−FT juices could only be noticed by experienced observers (1 < ΔE < 2). The calculated ΔE values for each pair of juices can be found in Table 3.

Table 3. Values of the parameter ΔE.

Juice Name	FT	HT	PD	SV	TB
FT		1.028342	3.028942	2.220151	3.157949
HT	1.028342187		3.897835	3.142123	4.161604
PD	3.028942138	3.897835		1.640639	1.271424
SV	2.220150753	3.142123	1.640639		1.402344
TB	3.157948776	4.161604	1.271424	1.402344	

3.2. Sensory Analysis of Color and Taste of Tomato Juices by Serialization Method

Statistical analysis of organoleptic evaluation of color showed significant differences in average acceptability ratings among respondents (p = 0.03). The respondents considered the color of SV juice to be the most acceptable. The second most attractive was HT juice, while respondents considered PD juice to be the least attractive in terms of color. A comparison of the acceptability of juice color with the results of spectrophotometric measurements shows that the least acceptable juice had the highest lightness (L* = 32.59), while the darkest HT juice (L = 29.67) was chosen second. Regarding the other juices, it is not possible to determine the relationship between the lightness of the juice color and their selection by respondents. The most acceptable SV juice was the reddest. No relationship was observed between the proportion of yellow and the choices of dietetics students (Table 4).

Table 4. Summary of the results of the color evaluation of tomato juices by the serialization method.

Juice Name	X ± SD	Med (IQR)	Sum of Ranks	Average Rank
SV	1.7 ± 1.12	1.0 (1.0)	102.5	1.708
HT	2.1 ± 0.87	2.0 (1.0)	126.0	2.100
FT	3.0 ± 0.80	3.0 (0.0)	177.0	2.950
TB	3.7 ± 1.02	4.0 (1.0)	219.5	3.658
PD	4.6 ± 0.99	5.0 (0.0).	275.0	4.583

X = average; SD = standard deviation; Med = median; IQR = quartile range.

Statistical analysis of organoleptic evaluation of taste showed significant differences in acceptability ratings among respondents (p = 0.028). SV and PD juices were indicated as the juices with the highest taste qualities. FT juice was rated the lowest. A comparison of juice flavor acceptability with spectrophotometric measurements showed no correlation between juices' flavor qualities and their color parameters (Table 5).

Table 5. Summary of tomato juice taste evaluation results.

Juice Name	X ± SD	Med (IQR)	Sum of Ranks	Average Rank
SV	2.65 ± 1.41	2.0 (2.0)	158.0	2.633
HT	2.8 ± 1.63	3.0 (3.0)	168.5	2.808
FT	2.95 ± 1.41	3.0 (1.5)	175.5	2.925
TB	3.13 ± 1.40	3.0 (2.0)	187.5	3.125
PD	3.52 ± 1.24	4.0 (1.5)	210.5	3.508

X = average; SD = standard deviation; Med = median; IQR = quartile range.

There was a faint, non-significant correlation between juice choices made based on taste and their ranking based on color. In no case was an increase in color acceptability accompanied by an increase in taste preference (Table 6).

Table 6. Rank correlation of the variables taste and color.

Juice Name	R Spearman	p-Value
HT	−0.001	0.992
SV	0.087	0.509
FT	−0.104	0.430
TB	0.157	0.230
PD	0.0514	0.696

PD juice made from fresh tomatoes was the brightest, and according to respondents, its color was the least acceptable, while its taste was rated highly. SL and HT juices made from concentrated juice were rated best for color and highest for flavor. SL was the most red, while HT was the least yellow. TB juice, which was a mixture of concentrated and fresh tomato juice, was the most yellow and rated poorly in both taste and color.

A comparison of consumers' choices of tomato juices with their prices showed that there was no correlation between consumers' choices and the market price of juices. The best-rated juice was the cheapest.

4. Discussion

An analysis of the literature shows that many studies can be found on measuring the color of objects, including food products. Few studies, however, are concerned with assessing the color of tomato juice. Much more often, researchers focus on the nutritional value of tomatoes and their health-promoting properties. The studies conducted on the color of tomato juice have mainly focused on the differences between organic and conventional crops, much less often focusing on differences due to the mode of production. Recent studies have consistently shown that color significantly influences consumer preferences and perceptions of food products. For instance, research by Spence et al. indicates that red is generally perceived as an attractive color in food products, often associated with ripeness, sweetness, and overall quality [22]. Similarly, a study by Garber, Hyatt, and Starr found that consumers tend to prefer brightly colored foods, associating them with freshness and better taste [23].

These trends highlight the psychological and sensory impact of color on consumer behavior, suggesting that the visual appeal of a product can be as crucial as its flavor and nutritional content. Our study aims to further explore these trends by analyzing how the color of tomato juice affects the preferences of dietitians, who play a pivotal role in guiding consumer choices through their professional recommendations [24].

From a dietitian's perspective, the concept of "taste" as a general attribute may not always align with the health-focused evaluation criteria used in dietary assessments. While participants in general studies might consider a sweet taste appealing, dietitians might not view sweetness as a positive attribute due to its association with added sugars and potential negative health impacts [25]. For instance, strength, as described by van Rompay et al., clarifies how sensory attributes like angular packaging can impart a perception of stronger, more intense taste, which can influence product evaluation beyond mere sweetness [26].

To better explain cognitive variables like appeal and taste in the context of participant judgment, it is crucial to distinguish between general consumer preferences and health-focused evaluations. Dietitians evaluate food products based on their overall nutritional profile and potential health benefits rather than just their sensory appeal. This includes considering factors such as natural ingredients, a lack of added sugars, and overall nutritional content. Therefore, explanations of appeal and taste should reflect these health-oriented criteria, acknowledging that attributes like strength, natural flavor, and overall nutrient density are more pertinent to dietetic evaluations than mere sweetness or immediate sensory gratification [25–29].

In the context of tomato juice, the red color is not only an indicator of freshness and quality but also correlates with the presence of lycopene, a beneficial antioxidant. This dual significance underscores the importance of color in both sensory perception and health-related attributes, making it a critical factor in product development and marketing strategies [30].

Tomato juice, although increasingly popular in the diet of Poles, according to a study by Jaskiewicz et al. [31], appears quite rarely in the diet of 230 students; only 14.8% of women and 16.4% of men from the University of Life Sciences in Lublin declared that they consume tomato juice.

In the literature, one can find results of spectrophotometric color measurement of various food products and correlations between product color and its influence on consumer choices. In a study by Łupina et al. [32], the authors analyzed 10 tomato juices, determining their color by spectrophotometric method, lycopene content, dry matter content, and performing an organoleptic evaluation. Five of the ten juices tested were identical in composition to the juices in our study. Despite identical composition, lightness, and parameters a and b in Łupina's study [32], they differed. Juice S6 (99% fresh tomatoes, salt, and water) had higher lightness, was more red, and was less yellow than PD juice. S2 and HT juices (100% tomato juice from concentrate and salt) had the lowest lightness, with S2 being brighter, more red, and more yellow than HT juice. S4 juice was lighter, redder, and less yellow than SL juice with the same composition. Juice S1 (concentrated tomato juice, tomato juice, and salt) had higher lightness, similar redness, and was less yellow than TB juice. S3 (similar to FT: concentrated tomato juice, tomato puree, salt) was brighter, redder, and yellower. Sensory evaluation results differed; juice S6 was rated best in Łupina's study [32] but worst in ours. SL and S4 juices were rated equally highly in both studies, with SL juice rated best for taste in both. FT juice was rated low, while its S3 counterpart was rated high. Differences in L*, a*, and b* parameters may be due to different measuring apparatuses or tomato species, not manufacturer differences.

Zhu et al. [33] performed sensory analysis between several juices, including tomato juices. One aspect of the juices' evaluation, as in their work, was their color and taste. The survey of 119 adults found that taste sensations after tasting were not consistent with color preferences. This result is similar to that obtained in the authors' work: a sample of Pudliszki juice rated low in terms of color was rated very high after tasting. In addition, Zhu [33] investigated that the stability of color, aroma, and taste decreased when juices were left longer than thirty minutes at room temperature.

A study by Bahçecl et al. [34] compared the color of three tomato juices produced by different concentration methods: conventional thermal evaporation, osmotic distillation, and membrane distillation (both cold and hot). The brightest juice was the least acceptable, least red, and most yellow, consistent with our findings, where the brightest PD juice was the least acceptable. In both studies, the darkest, reddest, and least yellow juice was rated highest in taste. Heating the juice did not significantly affect L*, a*, or b* parameters or acceptability ratings. Similarly, Oltman et al. [35] found respondents preferred red tomatoes over dark red, light red, orange, and yellow. A study on orange juice color among dietitians showed a preference for bright juices with an intense orange hue, similar to our finding that dietetics students preferred juices with the most red color and lowest lightness [36].

Color changes in food products are being studied by many scientists. Color change can be an indicator of failure to maintain product composition and quality during the storage process. Cais-Sokolinskaya [37] observed color changes in UHT milk with 2% fat stored at different temperatures for up to 24 weeks. Similar research was conducted by Popov-Raljić [38], studying milk with 1.6% and 3.2% fat content. Cais-Sokolinskaya et al. [39] also studied changes in the color of mozzarella cheese as influenced by storage and increasing temperature. Her study found a significant difference in the color of the products during storage. These studies indicate the high usefulness of color measurement to describe its quality. According to research, potential customers pay a lot of attention to the color of food, and so in a study by Wadhwani [40], the color of reduced-fat cheddar cheese, which was less yellow and more transparent, negatively affected consumer perception.

Strengths and Limitations

The research study has limitations, including sampling bias, homogeneity of the sample, and subjectivity of sensory evaluations. The sample was limited to female dietetics students, which may not be representative of the broader dietitian population. The participants had similar ages and educational backgrounds, which may not reflect the experiences of dietitians with more varied backgrounds. Sensory tests used in the study rely on subjective human assessments, which can introduce personal biases and preferences, limiting the objectivity of the results. Future studies should recruit a more diverse and representative sample of dietitians to increase the generalizability of the findings.

However, strengths should be mentioned. This study was conducted in a sensory analysis laboratory following PN-EN ISO 8589:2010 [20], which ensures high reliability and reproducibility of results. A Tri-Color SF80 spectrophotometer calibrated to precise standards was used, which increases the accuracy of juice color measurements. The use of sensory analysis among a specially selected group of active female dietetics students provides conclusions with high relevance and specialization in the evaluation of tomato juices.

5. Conclusions

This study found that color perception significantly impacts dietitians' ratings of tomato juices. Notably, juice rated as least attractive in terms of color received high flavor ratings, suggesting that color and flavor preferences may differ and should be considered separately in the production process. This indicates that dietitians may prefer more natural-looking products, even if those products are less intense in color. In contrast, the juice with the most intense red color was the most visually appealing, but this did not translate directly into taste preference. These findings partially confirm the research hypothesis that there is a significant relationship between color intensity, shade, and dietitians' preferences. The results suggest that other factors, such as composition or production method, may also influence ratings. For tomato juice producers, these results provide valuable insights into improving dietitians' perception of their products. Focusing on natural appearance and color intensity without compromising taste may attract more customers among diet professionals. The discrepancy between the sensitivity of human visual perception and instrumental color measurement underscores the necessity of using precise instrumental methods to detect color differences that might not be apparent to consumers but are important for maintaining product standards and consumer trust. In conclusion, this study reveals the complex dynamics between visual perception and food product evaluation, which has significant implications for the food industry, particularly in marketing and product development.

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Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Gębczyński, P.; Gwóźdź, E. Owoce pomidora źródłem karotenoidów. *Med. Rodz.* **2017**, *3*, 211–214. [CrossRef]
2. Alda, L.M.; Gogoasa, I.; Bordean, D.M.; Gergen, I.; Alda, S.; Moldovan, C.; Nita, L. Lycopene content of tomatoes and tomato products. *J. Agroaliment. Process. Technol.* **2009**, *15*, 540–542.
3. Skiepko, N.; Chwastowska-Siwiecka, I. Właściwości likopenu i jego wykorzystanie do produkcji żywności funkcjonalnej. *Żywność Nauka Technol. Jakość* **2015**, *6*, 20–32. [CrossRef]
4. Cámara, M.; Fernández-Ruiz, V.; Sánchez-Mata, M.C.; Cámara, R.M.; Domínguez, L.; Sesso, H.D. Scientific evidence of the beneficial effects of tomato products on cardiovascular disease and platelet aggregation. *Front. Nutr.* **2022**, *9*, 849841. [CrossRef] [PubMed]
5. Nakamura, A.; Itaki, C.; Saito, A.; Yonezawa, T.; Aizawa, K.; Hirai, A.; Suganuma, H.; Miura, T.; Mariya, Y.; Haghdoost, S. Possible benefits of tomato juice consumption: A pilot study on irradiated human lymphocytes from healthy donors. *Nutr. J.* **2017**, *16*, 27. [CrossRef] [PubMed]
6. Mihafu, F.D.; Issa, J.Y.; Kamiyango, M.W. Implication of sensory evaluation and quality assessment in food product development: A review. *Curr. Res. Nutr. Food Sci. J.* **2020**, *8*, 690–702. [CrossRef]
7. Nisha, P.; Singhal, R.S.; Pandit, A.B. Kinetic Modelling of Colour Degradation in Tomato Puree (*Lycopersicon esculentum* L.). *Food Bioprocess Technol.* **2011**, *4*, 781–787. [CrossRef]

8. Kazimierska, M. Obiektywna ocena barwy wyrobów użytkowych. *Technol. Jak. Wyr.* **2014**, *59*, 44–47.
9. Pathare, P.B.; Opara, L.; Al-Said, F.A. Colour Measurement and Analysis in Fresh and Processed Foods: A Review. *Food Bioprocess Technol.* **2013**, *6*, 36–60. [CrossRef]
10. Chudy, S.; Gierałtowska, U.; Krzywdzińska-Bartkowiak, M.; Piątek, M. Color measurement of dairy products. In *Contemporary Trends in Shaping Food Quality*; Piasecka-Kwiatkowska, D., Cegielska-Radziejewska, R., Eds.; University of Life Sciences in Pozna'n: Pozna'n, Poland, 2016; pp. 85–95.
11. The World's True Measure of Color. Pomiar Barwy Przetworów Pomidorowych. Available online: https://biosens.pl/produkty/stacjonarne/colorflex-ez-tomato (accessed on 10 May 2024).
12. Zahir, S.A.; Yahaya, O.; Omar, A.F. Correlating the natural color of tropical fruit juice with its pH. *Color Res. Appl.* **2020**, *46*, 467–476. [CrossRef]
13. Pecho, O.E.; Ghinea, R.; Alessandretti, R.; Pérez, M.M.; Della Bona, A. Visual and instrumental shade matching using CIELAB and CIEDE2000 color difference formulas. *Dent. Mater.* **2016**, *32*, 82–92. [CrossRef] [PubMed]
14. Breakthrough Innovation Poland, Nielsen IQ. Available online: https://nielseniq.com/wp-content/uploads/sites/4/2021/06/NielsenIQ_Breakthrough_Innovation_Poland_Report_2020.pdf (accessed on 10 May 2024).
15. Baryłko-Piekielna, N.; Matuszewska, I.; Szczecińska, A.; Radzanowska, J.; Jeruszka, M. Jakość sensoryczna rynkowych soków jabłkowych i pomarańczowych. *Żywność Nauka Technol. Jakość* **2002**, *1*, 34–51.
16. Budsławski, J.; Drabant, Z. *Metody Analizy Żywności*; WNT: Warszawa, Poland, 1972.
17. Tijssen, I.; Zandstra, E.H.; de Graaf, C.; Jager, G. Why a 'light' product package should not be light blue: Effects of package colour on perceived healthiness and attractiveness of sugar- and fat-reduced products. *Food Qual. Prefer.* **2017**, *59*, 46–58. [CrossRef]
18. Fenko, A. Influencing Healthy Food Choice through Multisensory Packaging Design: Designing New Product Experiences. In *Multisensory Packaging*; Velasco, S.C., Ed.; Palgrave Macmillan: New York, NY, USA, 2019; pp. 225–255. [CrossRef]
19. Labbe, D.; Pineau, N.; Martin, N. Food expected naturalness: Impact of visual, tactile and auditory packaging material properties and role of perceptual interactions. *Food Qual. Prefer.* **2013**, *27*, 170–178. [CrossRef]
20. *PN-EN ISO 8589:2010*; Sensory Analysis—General Guidelines for the Design of a Sensory Analysis Laboratory. Available online: https://www.intertekinform.com/en-gb/Standards/PN-EN-ISO-8589-2010-946437_SAIG_PKN_PKN_2744026/ (accessed on 10 May 2024).
21. *ISO 8587:2006*; Sensory Analysis—Methodology—Ranking. ISO: Geneva, Switzerland, 2006. Available online: https://www.iso.org/standard/36172.html (accessed on 10 May 2024).
22. Spence, C.; Velasco, C.; Knoeferle, K. A large sample study on the influence of the multisensory environment on the wine drinking experience. *Flavour* **2015**, *3*, 8. [CrossRef]
23. Garber, L.L., Jr.; Hyatt, E.M.; Starr, R.G., Jr. Measuring consumer response to food products. *Food Qual. Prefer.* **2003**, *14*, 3–15. [CrossRef]
24. Spence, C. On the manipulation, and meaning(s), of color in food: A historical perspective. *J. Food Sci.* **2023**, *88* (Suppl. S1), A5–A20. [CrossRef] [PubMed]
25. Lee, W.C.J.; Shimizu, M.; Kniffin, K.M.; Wansink, B. You taste what you see: Do organic labels bias taste perceptions? *Food Qual. Prefer.* **2013**, *29*, 33–39. [CrossRef]
26. van Rompay, T.J.; Deterink, F.; Fenko, A. Healthy package, healthy product? Effects of packaging design as a function of purchase setting. *Food Qual. Prefer.* **2016**, *53*, 84–89. [CrossRef]
27. Sirieix, L.; Delanchy, M.; Remaud, H.; Zepeda, L.; Gurviez, P. Consumers' perceptions of individual and combined sustainable food labels: A UK pilot investigation. *Int. J. Consum. Stud.* **2013**, *37*, 143–151. [CrossRef]
28. Spence, C.; Levitan, C.A.; Shankar, M.U.; Zampini, M. Does food color influence taste and flavor perception in humans? *Chemosens. Percept.* **2010**, *3*, 68–84. [CrossRef]
29. Heidari, M.; Khodadadi Jokar, Y.; Madani, S.; Shahi, S.; Shahi, M.S.; Goli, M. Influence of Food Type on Human Psychological-Behavioral Responses and Crime Reduction. *Nutrients* **2023**, *15*, 3715. [CrossRef] [PubMed] [PubMed Central]
30. Wirania, S.; Muhizam, M. Color on Food Packaging as Brand Visibility and Value Creation: A Systematic Review. *GATR-Glob. J. Bus. Soc. Sci. Rev.* **2022**, *10*, 267–284. [CrossRef]
31. Jaśkiewicz, T.; Sagan, A.; Bochniak, A.; Bronowicka-Mielniczuk, U.; Śląska-Grzywna, B.; Kuna-Broniowska, I.; Andrejko, D.; Wojtowicz, J.; Olejnik, J. Uwarunkowania oraz ocena spożycia przetworów pomidorowych wśród studentów. *Stow. Ekon. Rol. Agrobiznesu Rocz. Nauk.* **2014**, *16*, 167–174.
32. Łupina, K.; Kowalczyk, D. Lycopene content and antioxidant properties of selected tomato juices. *Badania I Rozw. Młodych Nauk. W Polsce* **2012**, *12*, 75.
33. Zhu, Y.; Charles, A.; Sims, K.; Klee, K.; Sarnoski, I. Sensory and Flavor Characteristics of Tomato. *J. Food Sci.* **2018**, *83*, 153–161. [CrossRef] [PubMed]
34. Bahçeci, K.S.; Akıllıoğlu, H.G.; Gökmen, V. Osmotic and membrane distillation for the concentration of tomato juice: Effects on quality and safety characteristics. *Innov. Food Sci. Emerg. Technol.* **2015**, *31*, 131–138. [CrossRef]
35. Oltman, E.; Jervis, S.M.; Drake, M.A. Consumer Attitudes and Preferences for Fresh Market Tomatoes. *J. Food Sci.* **2014**, *79*, 2091–2097. [CrossRef]
36. Kardas, K.; Kiciak, A.; Szynal, K.; Sitkiewicz, B.; Staśkiewicz-Bartecka, W.; Bielaszka, A. Assessment of the color of orange juice in the context of dietitians' food preferences. *Front. Nutr.* **2024**, *10*, 1328795. [CrossRef]

37. Cais-Sokolińska, D.; Pikul, J. Charakterystyka barwy mleka sterylizowanego UHT przechowywanego w różnych warunkach temperaturowych. *Chłodnictwo* **2003**, *38*, 32–35.
38. Popov-Raljić, J.V.; Lakić, N.S.; Laličić-Petronijević, J.G.; Brać, M.B.; Sikimić, V.M. Color Changes of UHT Milk During Storage. *Sensors* **2008**, *8*, 5961–5974. [CrossRef] [PubMed]
39. Cais-Sokolińska, D.; Danków, R.; Pikul, J. Stabilność i jakość barwy sera mozzarella w trakcie przechowywania. *Nauka Przyr. Technol.* **2009**, *3*, 1–7.
40. Wadhwani, R.; McMahon, D. Color of low-fat cheese influences flavor perception and consumer liking. *J. Dairy Sci.* **2011**, *95*, 2336–2346. [CrossRef] [PubMed]