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SENSORY EVALUATION AND ANALYSIS OF CHANGING BEVERAGE COLOR

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Abstract: From the perspective of sensory evaluation, this study combined vision, smell, and taste to assess whether a color alteration would affect sensory judgments. Therefore, color selection is an important component for drink packaging design. This research is conducted in two stages: (1) from the market research, literature review, and focus groups, four types of juice were selected for an experiment; and (2) to perform the experiment, two sessions of random taste of different fruit drinks were organized for subjects to identify them. The results revealed that if the color of a beverage matches its taste, the average rate of accuracy is above 94 %. Upon switching the taste and the color, only 41 % of participants identified certain flavors. The experimental results showed that the majority of participants chose to rely on vision of color, subsequently ignoring judgments of smell and taste. The results can act as a reference for fruit juice packaging designs. This study suggests that color schemes and product packaging have a close relationship of interdependence, particularly with natural food products' "appropriate or natural color" being emphasized by current consumers. Thus, an excellent drink packaging design and an appropriate implication of contents' color require serious consideration.

Keywords: *Sensory Evaluation, Color, Flavor Perception, Fruit-Flavored Beverage, Package Design*

1. Introduction and Motivation

1.1 Motivation

Overbeeke & Peters surveyed the taste of desserts packages, and the results showed that good packaging might be associated with corresponding flavor [1]. Underwood found that the package contributes to the interaction between consumers and the product, arousing shopping impulses in the consumer [2]. Garber, Hyatt, & Starr found that the color of food can render it significant and unique [3]. Koch & Koch stated that the color of food affects a consumer's taste [4].

Sight is the most seductive sense of all. It often overrules the other sense, and has the power to persuade us against all logic. Consider the food and color test that Dr. H. A. Roth performed in 1988. He colored a lemon-and-lime flavored drink in various degrees of intensity. He then asked hundreds of students to say which was the sweeter. Most of them had got it wrong. They believed that the stronger the color, the sweeter the drink. But in fact it was quite the opposite: the stronger the color, the more sour it actually was. [5]. In another test, C. N. DuBose asked the subjects to taste grape, lemon-lime, cherry, and orange drinks. There was no trouble correctly identifying the flavor if the color matched. But when color and flavor were switched, only 30 percent of those who tasted the cherry could identify the flavor. In fact, 40 percent thought the cherry drink was lemon-lime [6].

This study discusses the sensory evaluation of color modification of beverages to assess the reaction of smell and taste with the occurrence of color changes.

Four experiments are reported on how design engineering students can express the taste of a dessert in its packaging and how people experience this expression. Experiments show that people are able to match desserts and packaging designs on the basis of all the information available, and of mainly color information [7].

Numerous studies have discussed the relations of senses, and extended this notion to the effects of packaging colors because consumers tend to be affected by preferences or deviation from the appearance of products. Considering these factors, designers select the proper packaging color to match the content of the products to attract consumers.

1.2 The purpose

This study discusses how the color of beverages is associated with sensory evaluation because taste is tied with other senses. For example, green packaging reveals a sense of sourness, whereas pink packaging evokes a sense of sweetness and softness. Because these senses interact with each other while color-change occurs, this study arranged an experimental group and a control group to compare and analyze the results of the experiment, to provide further suggestions for product design.

1) To discuss sensory evaluation and analysis of changing beverage color.
2) To discuss how the color affects the participants in their sensory evaluation of smell and taste.
3) To discuss the appropriate or natural colors used in packaging design.

1.3 Literature Review

Sensation refers to how an individual feels regarding the exterior or the mode of perceiving information in the world. Aristotle was the first to list the five senses: sight, hearing, smell, taste, and touch [8].

1.3.1 Sensory Evaluation

Sensory Evaluation comprises using the five sensory systems (vision, smell, taste, touch, and hearing) as instruments to combine psychology, chemistry, and statistics to measure and analyze food products, an evaluating method that detects the differences of the quality of products. Academia defines it as "scientifically exploring how to cause, measure, analyze, and interpret the characteristics of the five sense responses to products. The objective is to collect subjective reaction data in scientific and objective methods. In the beginning, this approach was used mainly by the perfume industry, though later adopted by the food and beverage industry, and even the textile and printing industries in Europe and North America.

Sensory evaluation seeks to replace machinery-checking systems with human senses, and examines human preferences and sensitivities. Sensory evaluation is widely used in new product development, product improvement, quality maintenance, and market research, such as in the food industry, often used to check food color, taste, smell, and organization.

1.3.2 Synesthesia of color and smell

People can close their eyes, cover their ears, refrain from touch, and reject taste, but smell is used to inhale oxygen, at approximately 20,000 times daily [9], which means that it is the one sense that cannot be switched off.

Psychologist Constance Classen stated that "Smell isn't just a perception that causes a physical and psychological and reaction; it is a phenomenon that reflects culture, society, and history." [10]. The study conducted by Cervonka showed that, compared to other senses, smell is superior for evoking customer emotions [11]. Henry Gleitman showed that other than conveying the inner feeling of the body, and informing the taste of food, smell can also convey messages to external objects of the body [12]. Shepherd stated that smell affects people's preferences and cravings for food. In the human brain, the perceptual systems are closely linked to systems for learning, memory, emotion, and language and the neural mechanisms contribute to food preferences and cravings [13].

The Functional Examination Department of Japan Science and Technology Alliance conducted a synesthesia-related investigation of smell and color, the results of which are detailed in Table 1, as follows:

Table 1. Synesthesia-related investigation of smell and color

Odor	Color
Lemon	Bright
Peach	Distinct opacity of the red
Green nuts	Deep green
Mint	Clear light green
Western Fir	Dark yellow
Amber oil	Dark cloud of purpurin
Musk	Pale yellow

The results of synesthesia for taste and color from the students of the Design department of Japan Chiba University are shown in Table 2 [14], as follows:

Table 2. Synesthesia for taste and color

Sense of Taste	Color
Sweet	Pink, white cake feeling
Hot	Red pepper and yellow curry muddy
Salty	The thought of light gray salt
Bitter	Concentration of green tea and coffee brown
Astringent	Dark brown immature persimmon
Acid	Like orange yellow green immature and

The aforementioned study shows that each vegetable or fruit has its own scent and original color, that lemon conjures a feeling of bright yellow and yellow orange. The taste and color of the subject are thus difficult to separate.

1.3.3 Synesthesia of color and taste

Taste is detected by special structures called taste buds, of which females are more generally believed to possess more sensitive taste compared to males. The belief is well founded because females have more taste buds than males. Humans have approximately 10,000 taste buds, mostly concentrated on the tongue, with a few at the back of the throat and on the palate. Everyone tastes differently. As humans grow older, their sense of taste change, becoming less sensitive, making it more likely that they enjoy foods they once considered “too strong” as children. Four types of taste buds exist: sensitivity to sweet, salty, sour, or bitter chemicals, respectively. Different taste areas of the tongue are superior compared to others for detecting certain flavors because each type is concentrated in different regions of the tongue. The tip is optimal for sweetness (noted in a child’s preference to lick a candy sucker rather than to chew it), sour on the sides, bitter at the back, and saltiness all over. Taste is formed from the mixture of these basic elements. Different tastes are distinguished by various combinations and a more sophisticated sense of smell [15].

Smell could exist without taste, though taste existing without smell is impossible. Taste is a near sense, a result of the direct contact between chemical stimuli and the receptor. Taste buds are receivers of taste for humans. Each individual owns an average of ten thousand taste buds; buds are highly sensitive to chemicals dissolved in water.

In 1924, H. Henning proposed Taste Space: the tastes are located on the vertices in the tetrahedron of Taste Space. They are salty, sour, sweet, and bitter [16]. In 1966, Bekesy applied different substances onto different areas of the tongue, and found that each area responds mainly to one of the four tastes. The four main natures are: sweet, sour, salty, and bitter [17].

Vision is the most striking of all the senses because it often rejects other senses as well. Vision can convince humans to deny all logic. Color taste arises from the hue. People often sense taste via visual stimulation of the color of foods, such as green and green yellow, where green can evoke sourness. Pure colors, such as magenta, orange, and yellow orange, are sweeter. The impression of bitterness comes from burnt food or thick black traditional Chinese medicine and coffee. The low value colors and low saturation colors are dark colors, such as dark brown, black, and dark gray. The stimulation of chili is the representation of spiciness, which can be presented as pure red, dark red, mixed with yellow, green, or dark green. Gray green, dark green, and olive green evoke a sense of dryness.

Sensitivity of taste differs with different areas of the tongue. The tip of the tongue possesses the most sensitive cells for sweetness, for sourness on the two sides, for bitterness at the base of the tongue, and the sensitive cells for saltiness are over the entire surface. Taste receptor cells respond the most to sourness, sweetness, bitterness, and saltiness, and the qualities of the best responses are directly translated into codes [18]. Perhaps this code has included other related effects that are generated together at that moment, suggested in numerous related studies.

1.3.4. A Study on Chromaesthesia of Taste and Smell

Yu-Chun Hsu’s study, Color Combination Design on the Image Evaluation of Taste and Olfaction, involved applying the databases of known color imageries for taste and smell to predict the level of imagery for unknown color vocabularies of taste and smell. The results showed that the perceptions of subjects for color and the vocabularies of taste are mostly an association from the color of food to the taste of food [19].

1.3.5 The Research on Synchronizing of Bottle Shape and Taste from Food Packaging

A perfect packaging design can catch consumer attention when they intend to purchase a product from a shelf displaying numerous items. A product’s appearance might alter the choice of consumers, which is why marketers focus on colors to mark a difference for determining the success of products.

J.Y. Zhu stated that coloring decides how the package works because coloring influences human perception and leads them to targeted items or highlighted sections. An experiment conducted in the U.S. tested housewives and coffee-drinking. They were asked to drink four cups of the same coffee. Each cup of coffee sat next to a coffee can of one color with no patterns. The results showed that 80 % of the women thought that the coffee from the red can was thicker; 87 % believed that the coffee from the blue can was milder; 73 % thought the coffee from the brown can to be thicker; 79 % thought that the coffee from the red can was thinner. This shows that the first impression of color influences people to perceive differently. [20].

Figure 1. Beverage packages according to their fruit colors

Figure 2. Beverage flavors differentiated by colors

1.3.6 Summary

In summation, the odors of fruits imply their significance and representation of their own colors. In other words, the colors of food objects are linked to their smell and taste, such as lemon or grape, which have their fixed linkage in certain colors regarding the odors of these fruits. For example, lemon or grape smell of their original colors, and the color of food is thus naturally associated with its smell and taste.

Juice products in supermarkets are mostly labeled and differentiated by the colors of their packages, which are the original colors of the fruit, to attract the attention of consumers and help them recognize the brand, the quality, and the taste of the fruit. Therefore, blue and green are widely used in cold drinks to relax or cool down consumer anxiety. Color communication has thus been increasingly valued, heightening the experience and spirit of products.

2. Methods

This research is conducted via the Experimental Method to investigate the relationship between color and the sense of smell and taste according to two stages: the taste (sour, sweet) and smell (fruity scent) of the fruit beverages would be switched, and the same participants would taste the beverages from the experimental group and the contrast group. The colors of the selected juices are changed from their original color to examine whether the change of color affects the smell and taste of participants.

2.1 Experimental utensils and environment

2.1.1 Experimental utensils

Different flavors of the beverages are used as the variables, as follows:

1) Participant: by non-probability sample, the subjects comprise 124 students with a background in design. The subjects included 39 males and 85 females. 64 subjects (between the age of 18 and 25) are from Taichung Institute of Technology, and 60 subjects of the same age group are from the department of Media Design of Asia University.

2) Materials and apparatus:

(1).Beverages of the original colors: grape's color , orange color, lemon's color, and strawberry's color beverages.

(2).Beverages of changed colors: orange color (changed from grape's color), grape's color (changed from orange color), strawberry's color (changed from lemon's color), and lemon's color (changed from strawberry's color).

(3).Containers: drinks are served in transparent disposable cups of 20 cc.

Table 3. Basic tastes and colors of the flavors

Fruit	Basic taste	Original colors	Change colors
Grape	Sweet	Purple	Orange
Orange	Sweet	Orange	Purple
Lemon	Sour sweet	White translucent	Red Orange
Strawberry	Sour sweet	Red Orange	White translucent

2.1.2 Experimental environment

Environment: classroom with gray walls and general educational lighting.

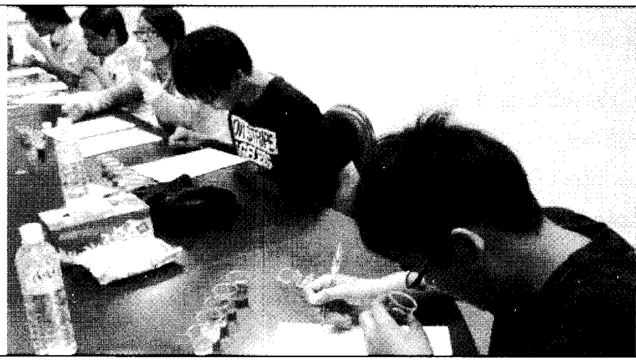


Figure 3. Participants evaluating the beverages

2.2 The procedures

The experimental beverages are of the same recipe and color as their market counterparts. Participants tasted 20 cc of juice, ascertaining that the solution reached all the areas inside the mouth, including the root of the tongue, and as many nerve endings as possible. Each participant was provided a bottle of mineral water for rinsing their mouths and resting for 60 seconds upon tasting each flavor, before proceeding to the next three beverages. In the experiment, participants were not allowed to eat, drink (except water), or smoke an hour before testing. Before the experiment, participants rinsed their mouths with water, and were asked not to wear lipstick or perfume.

Table 4. The ratio of sugar to acid in beverage

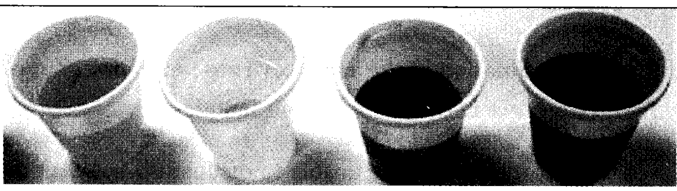
Juice	Grape	Orange	Lemon	Strawberry
Color	R_{40} : 0.0095 % B_1 : 0.0005 %	Y_4 : 0.019 % Y_5 : 0.001 %		R_{40} : 0.0028 % R_6 : 0.001 % Y_4 : 0.0002 %
Acid ratio	Malic acid : 0.007 % Tartaric acid : 0.01 % Citric acid : 0.1 %	Citric acid : 0.2 % Sodium citrate : 0.05 %	Citric acid : 0.25 % Sodium citrate : 0.1 %	Citric acid : 0.25 % Malic acid : 0.05 %
Sugar ratio	8 %	10 %	9 %	10 %
Flavor	0.250 %	0.250 %	0.25 %	0.25 %

(All the samples of the experiments in this study were provided by SAN-EI GEN E.F.I. INC., Japan.)

2.2.1 The first step / control groups

(Color matches flavor)

Participants randomly selected beverages and attempted to identify the flavors while relying on smell and taste. They recorded their answers sequentially before rinsing their mouths for 60 seconds and proceeding onto the next flavor.

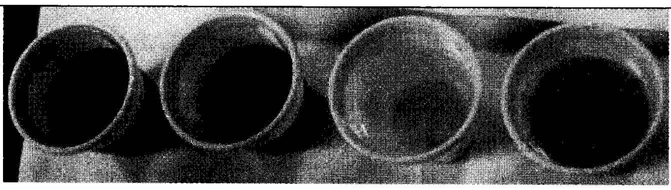


Orange Lemon Strawberry Grape

Figure 4. Standard Color Beverage Sample

2.2.2 The second step / experiment groups

(Color-changed beverage) Repeat the same steps.



Orange、 Lemon、 Strawberry、 Grape

Figure 5. Color Modification of the Beverage Sample

2.3 Statistics and Analysis

To assess whether the average numbers of the difference was apparently above the level of statistical significance, upon completing the experiment, the data was processed in SPSS17, examined in chi-square to compare the differences between the two steps.

3. Results and Discussion

The first stage comprised selecting four juice flavors from market research, references, and focus groups. The flavors were grape, orange, lemon, and strawberry. The second stage was conducted using the experimental method via food sensing, combining vision, smell, and taste to explore whether the color-change of juice affects the judgments of smell and taste. The results are as follows:

3.1 The results of the drinks in their original colors

The sensory evaluation of the four beverages in their original colors showed that the majority of testers were able to determine them correctly: 123 people (99.19%) determined the grape flavor; 117 (94.35%) were correct regarding the orange flavor; only 108 testers (87.10%) were able to determine the lemon flavor; and 124 testers (95.97%) were able to determine the strawberry flavor. The details are listed in Table 5. An examination of the results of these beverages in their original colors yields 17.689, $P<.01$ of the chi-square, which shows that the rate of accuracy reached a level of significance (Table 5); another test conducted thereafter revealed that a significant difference exists between the lemon flavor and the other three flavors, that the value of the significant differences between the lemon flavor and the grape flavor is $P=.000$, that the value of the significant differences between the lemon flavor and the orange flavor is $P=.014$, and that the value of the significant differences between the lemon flavor and the strawberry flavor is $P=.003$. No significant differences exist in the rate of accuracy for the grape, orange, and strawberry-flavored beverages. This result shows that, unlike the other three beverages, the color of the lemon-flavored beverage being 'white and translucent" is not associated with its original color, becoming a difficulty in judgment and affecting the accuracy rate.

Table 5. The beverages in original color

Beverages	Correct (%)	Mistake (%)	Total (%)
Grape	123 (99.19 %)	1 (0.81 %)	124 (100 %)
Orange	117 (94.35 %)	7 (5.65 %)	124 (100 %)
Lemon	108 (87.10 %)	16 (12.90 %)	124 (100 %)
Strawberry	119 (95.97 %)	5 (4.03 %)	124 (100 %)
Pearson Chi-Square=17.689	**Asymp. Sig. (2-sided) .001**		

3.2 The analysis of the color-changed flavors

Most participants failed to identify the beverages correctly after the colors were changed; 49 participants (39.51%) identified the grape-flavored solution, 43 participants (34.67%) identified the orange-flavored solution, slightly fewer participants, 53 of them (42.74%)

identified the lemon-flavored solution, and 58 participants (46.77%) identified the strawberry-flavored solution.

Upon calculating the numbers of determining the flavors of the color-changed fruit beverages, the result of chi-square value 4.028a, p=.258 shows that the accuracy rate did not reach a level of significant difference, as shown in Table 6.

Table 6. Chi-Square Tests

Fruit	Correct (%)	Mistake (%)	Total (%)
Grape	49 (39.51 %)	75 (60.48 %)	124 (100 %)
Orange	43 (34.67 %)	81 (65.32 %)	124 (100 %)
Lemon	53 (42.74 %)	71 (57.26 %)	124 (100 %)
Strawberry	58 (46.77 %)	66 (53.23 %)	124 (100 %)
Pearson Chi-Square=4.028a		**Asymp. Sig. (2-sided) .258**	

3.3 The analysis for the fruit beverages of normal colors and the fruit beverages of changed colors

According to the chi-square test, the Pearson chi-square value equals 320.471a, (p<.01) indicating that a significant accuracy difference of smell and taste exists between the original-colored beverages and the color-changed beverages (Table 7). The possibility of this result may be because the original colors of the beverages correspond to those of the fruits, though upon modifying the colors, they are no longer associated with the original colors of the fruits, causing visual difficulty for identification and affecting the accuracy rate.

Table 7. Chi-Square Tests

	Value	df	Asymp. Sig.(2-sided)
Pearson Chi-Square	320.471[a]	1	.000
Continuity Correction[b]	318.048	1	.000
Likelihood Ratio	358.358	1	.000
N of Valid Cases	992		
a. 0 cells (.0 %) have expected count less than 5. The minimum expected count is 161.00.			
b. Computed only for a 2x2 table			

3.4 The examination of the accuracy rate for normal fruit beverages between males and females

Most participants were able to identify the fruit beverages in their original colors; 31 males (100 %) and 92 (98.92 %) females identified the grape-flavored solution; 29 males (93.54 %) and 88 females (94.62 %) identified the orange-flavored solution; 27 males (87.10 %) and 81 females (87.10 %) identified the lemon-flavored solution; and 30 males (96.77 %) and 89 females (95.70 %) identified the strawberry-flavored solution.

Upon calculation of the accuracy rates of determining the flavors of the original colors of the fruit beverages between males and females, the result of chi-square value .012a, p=.912 shows that the accuracy rate did not reach a level of significant difference. Further examination shows that the accuracy rate of identifying the lemon-flavored solution remains at 87.10 %. The rate is the same between males and females as the former result of the experiment in Section 3.1, where the rate is lower compared to the other three solutions. The details are shown in Table 8.

Table 8. Chi-Square Tests

Beverage	Male Correct	Female Correct	Total (%)
Grape	31 (100 %)	92 (98.92 %)	123 (99.19 %)
Orange	29 (93.54 %)	88 (94.62 %)	117 (94.35 %)
Lemon	27 (87.10 %)	81 (87.10 %)	108 (87.10 %)
Strawberr	30 (96.77 %)	89 (95.70 %)	119 (95.97 %)
Pearson Chi-Square=.012[a]		**Asymp. Sig. (2-sided) .912**	

3.5 An examination of the accuracy rate for color-changed fruit beverages between males and females

Most participants were unable to distinguish between the different fruit beverages when the colors changed; 8 males (25.81 %) and 41 females (44.09 %) were able to identify the grape-flavored solution; 9 males (29.03 %) and 34 females (36.56 %) could identify the orange-flavored solution; 14 males (45.16 %) and 39 females (41.94 %) identified the lemon-flavored solution; 13 males (41.94 %) and 45 females (48.39 %) were recognized the strawberry-flavored solution.

After calculating the accuracy rates for determining the flavors of the color-changed fruit beverages between males and females, the result is chi-square value 2.026a, p=.155, which shows that the accuracy rate did not reach a level of significant difference, as detailed in Table 9.

Table 9. Chi-Square Tests

Fruit	Males Correct (%)	Females Correct (%)	Total (%)
Grape	8 (25.81 %)	41 (44.09 %)	49 (39.51 %)
Orange	9 (29.03 %)	34 (36.56 %)	43 (34.68 %)
Lemon	14 (45.16 %)	39 (41.94 %)	53 (42.74 %)
Strawberry	13 (41.94 %)	45 (48.39 %)	58 (46.77 %)
Pearson Chi-Square=2.026[a]		**Asymp. Sig. (2-sided) .155**	

3.6 Limitations of the study

1) To achieve more accurate results, the study is divided into two ranges: First, natural fruits are used as the samples; functional drinks, lactic acid drinks, concentration fruit juices, and sports drinks are excluded.

2) Study samples: the four flavors of sweet and sour tastes: grape, orange, lemon, and strawberry. The selections are based on the common drinks in the Taiwanese market.

4. Conclusions

After analyzing the experiment and the aforementioned results, this study reached the following conclusions:

1) In the first step, when participants tasted the grape, orange, lemon, and strawberry flavored beverages in their corresponding colors, 99 % (123/124) recognized the grape flavor; 94 % (117/124) recognized the orange flavor; 87 % (108/124) identified the lemon flavor; and 95 % (119/124) recognized the strawberry flavor. Upon calculating the accuracy rates of determining the flavors of the fruit beverages in their normal colors, the result, chi-square value 17.689, $P < .01$, shows that the accuracy rate reached a level of was significantly different. A further examination revealed that the significant difference of accuracy rate showed that the lemon-flavored solution was the hardest to identify compared to the other three flavored fruit beverages; no significant differences of accuracy existed for determining the other three flavors. The result is possibly caused by the fact that unlike the other beverages, the color of the lemon-flavored solution is white and translucent, meaning that this color and the fruit's original color are not apparently connected, thus causing the difficulty of identification for the participants and affecting the accuracy rate.

2) Once the colors of the beverages were changed in the second step, participants began tasting, and only 39.51 % (49/124) could identify the orange-yellow-colored solution of the grape flavor; 34.68 % (43/124) could identify the magenta-colored solution of the orange flavor; 42.74 % (53/124) could identify the red-orange-colored solution of the lemon flavor; and 46.77 % (58/124) could identify the white-translucent-colored solution of the strawberry flavor. Upon calculating the accuracy rates of determining the flavors of the color-changed fruit beverages, the result of chi-square value 4.028a, $p=.258$ shows that the accuracy rate did not reach a level of significant difference.

3) Significant differences are present between the first step of the normal colors and the second step of the changed colors ($p < 0.001$), though no differences exist in the accuracy rate between males and females.

4) If the beverage flavors were matching their original colors, 94 % of participants were able to recognize it. Once the flavor and color were switched, only 41 % could recognize the flavor; this study therefore suggests that vision affects the sensory judgment of smell and taste, meaning that oftentimes the color that the eye perceives might lead to errors in judgment, and the senses of smell and taste should be incorporated when evaluating. The results above are similar to the test results of CN DuBose, whose study comprised participants tasting beverages and identifying the flavors of grapes, lemon, cherry, and orange, and only 30 % could identify the cherry flavor when its color and flavor were switched and 40 % thought that the cherry-flavored beverage was lemon flavored. When the color changed, 59 % of participants were affected in the judgment of smell and taste when the beverage colors changed; the color scheme of fruit beverage package must therefore be highly affective for smell and taste. The color scheme of package design is interdependently related to the product. Color is of equal importance with the package, especially when natural food products often provide a solid notion of "Appropriate or Natural color" to consumers. A good food packaging design must therefore apply the colors that properly intimate its content.

5. Recommendations for Future Research

Since a wide variety of options are available for commercial beverage packaging, this study selected fruit-flavored beverages for its experimental samples and did not cover other possibilities; more detailed results would thus be available if other flavor samples are considered.

6. Acknowledgment

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