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Colour Design for Carton-Packed Fruit Juice Packages

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Abstract

The present research studies the relationships between observers' expectations for 7 fruit juice packages and the colour design of the package. To do this, a two-stage experiment was conducted. At the first stage, we studied perceived colours for the fruit images shown on each package. At the second stage, fruit juice packages with 20 package colours were rated using 5 bipolar scales: colour harmony, preference, freshness, naturalness and product quality. The experimental results show that the observers tended to perceive fruit image colours lighter and more saturated than those measured using colour measuring instruments. Using factor analyses, we classified the 5 bipolar scales into 2 factors: Product Preference and Freshness. Package colour design was found to have significant impacts on both factors: similarity in chroma and hue between package colour and perceived fruit colour would lead to high product expectations.

Keywords

colour design; colour harmony; product expectation; perceived image colour

Package appearance is considered a 'salesman on the shelf'. As a primary vehicle for communication and branding (Rettie & Brewer, 2000), package design can influence consumers' purchase decision making. Fruit juice is considered one of the "low involvement products" as defined by Harris (Harris, 1987). Colour and graphics in fruit juice packages, two key elements of total appearance in a package design (Hutchings, 2003), have a strong impact on marketing communications and consumer decision-making. This is because evaluation of actual product quality is sometimes ignored for low involvement products, and graphics and colour become more critical (Grossman, & Wisenblit, 1999).

In the past, colour selection in commercial design is a trial and error process (Chepeel, 1951). This process is either based on the consumer's past experiences or relying on subjective recommendations by colour consultants. With this somehow risky colour design process, sluggish sales may happen and this may also lead the company to redesigning and re-launching the products (Ramirez, 1990). During the past decade, colour was involved in more and more studies related to marketing (Henson, Barnes, Livesey, Childs & Ewart, 2006; Grimes & Doole, 1998; Corn, Chattopadhyay, Yi & Dahl, 1997; Silayoi & Speece, 2004). These studies focused on the effects of colour on consumers' purchase decision making where colour preference and associations have been the main interests. Due to insufficient and improper colour sampling, these results could not provide a comprehensive understanding about any relations between colour and consumers' responses and could not quantify such relations. For example, Hutchings stated that intensifying fruit colours could strengthen expectation for the juice flavour. But what is the right colour for this fruit? How do we design colours for different juice packages both to strengthen expectations about different flavours and to make the juice packages easily distinguished from each other?

Our previous study showed that people tended to prefer orange juice with a package colour design that appears harmonious (Wei, Ou & Luo, 2007). An orange juice package with harmonious colour design tended to be regarded as having high quality and being healthy. In addition, packages with highly saturated package colours were seen as being fresher than those with greyish colours, and people tended to prefer the former to the latter.

Based on these findings, the present study aims to find (1) how observers perceived the colours of the fruit images shown on juice packages; (2) observes' preference for and expectations of different kinds of fruit juice; and (3) the relationships between package colour design and observers' expectations of the juice products. To this end, the juice packages used in this study included those of orange, apple, cranberry, pineapple, grapefruit, strawberry and tomato juices, the 7 best sold fruit juice in the UK.

Experimental Design

A two-stage psychophysical experiment was carried out using the method of colour adjustment and categorical judgment. The objective of the first stage was to examine observers' perceived colours of the fruit image. The second stage of the experiment dealt with the relationship between colour design of packaging appearance and observers' expectations to the product.

Observer

Ten male and 10 female observers with normal colour vision participated in this experiment. They are either postgraduate students or academic staff members at the University of Leeds. The average age was 26.

Stimuli

Seven most popular fruits in UK juice market were involved in this study, including orange, apple, cranberry, pineapple, grapefruit, strawberry and tomato juices. The fruits were photographed under a D65 daylight simulator in a viewing cabinet with a neutral grey background. A carton package of fruit juice was also photographed under the same conditions. For the first stage of the experiment, 7 fruit images were used as the visual stimuli to define salient areas and to be the references of colour adjustments. Figure 1 shows the stimuli for the first stage of the experiment. For the second stage, the appearance of each juice package image was manipulated using 20 colours (i.e. the background colour in a package design) and 7 fruit images. As shown in Figure 2, these 20 colours were selected to cover a big gamut in CIELAB colour space. This resulted in 7 x 20 = 140 visual stimuli for used in the second stage of the experiment. Two examples are shown in Figures 3(a) and (b).

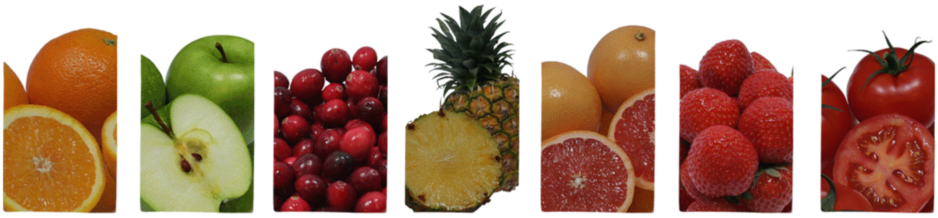


Figure 1. Seven fruit images: the stimuli of the first stage of the experiment.

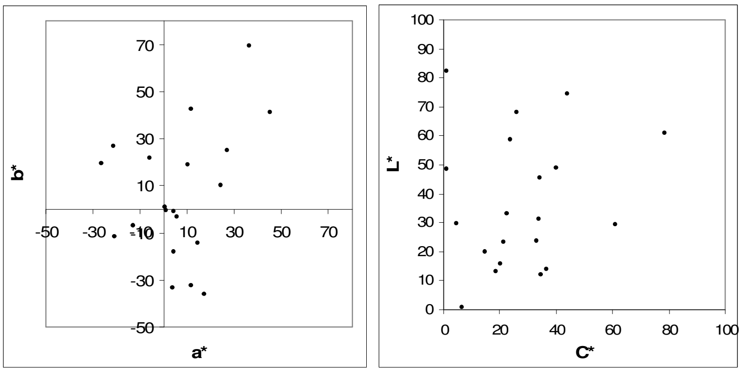


Figure 2. The distribution of 20 package colours in CIELAB colour space. a* and b* represent scales of reddishness (with positive values) / greenishness (negative) and yellowishness (positive) / bluishness (negative); L* means a scale of lightness (from dark to bright with increasing values); C* means a scale of colourfulness.

Figure 3. Two examples of experimental stimuli: (a) orange juice with a white package colour and (b) tomato juice with a deep green package colour.

Bipolar scales

Five bipolar scales were used in this study to measure observers' responses/expectations while viewing the stimuli. The first scale, named colour harmony, demonstrates how harmonious or disharmonious the colour scheme in each package design appeared. The second scale, named preference, demonstrates how consumers tended to like each fruit juice when they see the package image. The other three scales, named freshness, naturalness and product quality, demonstrate how consumers expect each fruit juice to be when they saw the package image. These three scales were found to be the three major factors for British consumers while purchasing fruit juices, as reported in a media and market research by the Mintel International Group (Mintel International Group Ltd., n.d.). Each scale was categorised into 10 points for each observer to choose from as a response, with 5 negative (i.e. from -5 to -1) and 5 positive (i.e. from 1 to 5). There is no neutral answer as these are forced-choice scales. These 10 points were in the form of 10 buttons shown on a calibrated Cathode Ray Tube (CRT) monitor. Above the 10 buttons is the visual stimulus in the form of an image, also shown on the same display.

Procedure

The experiment was conducted in a darkened room with the illumination only coming from the CRT display. This CRT was used to present visual stimuli at both stages of the experiment. Before the experiment, colour characterisation for the CRT was done so that the RGB digital counts can be converted to XYZ and then to CIELAB colour specifications. The advantage of using CIELAB rather than RGB is that the former colour space is device-independent and the latter device-dependent, and that CIELAB is a perceptual colour space with good uniformity.

At the first stage of the experiment, 20 observers were asked to identify in the 7 fruits images salient areas that they thought best represented any parts of the images in terms of colour. For each chosen area, observers were then asked to adjust hue, saturation and lightness of a colour patch presented next to the fruit image, in order for the colour patch to match the perceived colour in the chosen area.

At the second stage, observers were asked to rate 140 fruit juice images, presented randomly, on each of the 5 bipolar scales. During the task, observers provide their responses by clicking one of the 10 buttons shown on screen. The observers' responses were automatically recorded by the computer programme.

Results

Perceived colours in fruit images

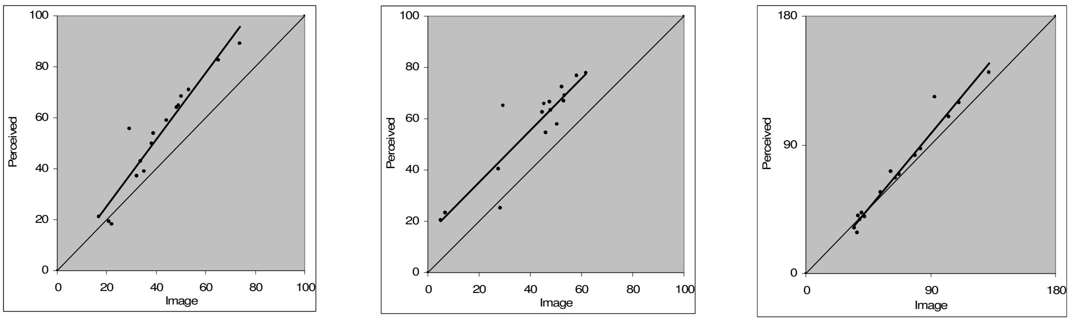
According to experimental data, results of salient-area-segmentation were found to vary from fruit to fruit. Totally 16 salient areas were found for the 7 fruit images, as shown in Table 1. Colours of these 16 areas were then calculated by averaging L*, a* and b* of all pixels within each area.

These colours were compared with the matched colour patches. It was found that each colour patch was lighter and more chromatic than the corresponding image colour; the lighter the image colour, the larger the lightness difference between image colour and colour patch. There was little hue difference between the two. Figures 4 (a)-(c) show relationships between image colours and colour patches in terms of L*, C* and hue.

Figure 5 shows how L* and C* interact in terms of colour difference between fruit image colours and colour patches. The solid dots denote the image colours and the open dots denote the colour patches. It is clear that in the L*-C* plane, the colour patches are located outside the image colours. If we draw a line starting from each colour patch to its corresponding image colour and keep going until it arrives at either axis, all these 16 lines will form a radiation with a centre point approximately located at L* = 20 and C* = 0.

Table 1. The salient areas of the 7 fruit images. The numbers followed in each area denote the frequency of being selected as a salient area.

Fruit	Salient areas	Fruit	Salient areas
Orange	Flesh(20), peel(20) and inner side	Grapefruit	Flesh(20) and peel(20)
	of the peel(9)	Strawberry	Peel(20)
Apple	Flesh(18) and peel(20)	Tomato	Flesh(15), peel(20) and stalk(7)
Cranberry	Dark(20) and bright(20) parts		
Pineapple	Flesh(20), peel(15) and crown(15)		



(a) Relationship of L*　(b) Relationship of C*　(c) Relationship of h

Figure 4. Relationship between image colours and colour patches in terms of L*, C* and h.

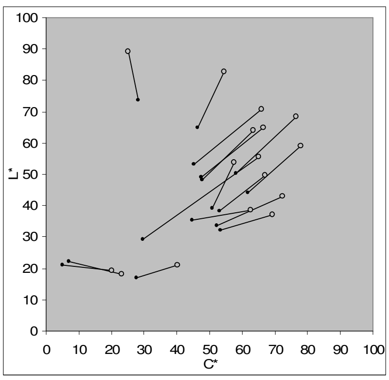


Figure 5. The distribution of image colours (solid dots) and corresponding perceived colours

(open dots) in the L*-C* plane.

On the basis of this geometric pattern in CIELAB space, a numerical model for predicting perceived colours in an image was developed, as given in equation (1).

$$
\begin{aligned}
L^* &= g(L_0^*, C_0^*) \times \left(L_0^* - 21.03\right) + 25.6 \\
C^* &= 1.04 \times g(L_0^*, C_0^*) \times C_0^* - 4.79 \\
h &= 1.17 \times h_0 - 7.27 \\
\text{where } g(L_0^*, C_0^*) &= \frac{\left(\left(L_0^* - 21.03\right)^2 + C_0^{*2}\right)^{1/2} + 20.17}{\left(\left(L_0^* + 21.03\right)^2 + C_0^{*2}\right)^{1/2}}
\end{aligned}
\qquad (1)
$$

L_0^*, C_0^* and h_0 are CIELAB lightness, chroma and hue of an image colour. L*, C* and h are CIELAB lightness, chroma and hue of the predicted "perceived colour".

To summarise, the salient areas, which were selected by the observers, determines what and how many colours there appeared to the observers in each fruit image. The model for predicting perceived colours determines the colours that a viewer may actually perceive while seeing a fruit image. Table 2 presents the perceived colours for the 7 fruit images in terms of lightness (L*), chroma (C*) and hue (h). These data were used in the following data analysis.

Table 2. The perceived colours in the 7 fruit images

		L*	C*	h
orange	flesh	68.35	76.63	66.73
	peel	58.96	77.82	56.95
	peel(inner)	82.72	54.59	87.03
apple	flesh	89.04	25.12	109.78
	peel	63.92	63.43	119.25
cranberry	dark part	21.18	40.32	28.42
	bright part	49.68	66.96	31.72
pineapple	flesh	70.83	65.97	82.71
	peel	55.50	64.99	69.15
	crown	19.29	20.21	140.26
grapefruit	flesh	38.74	62.67	37.46
	peel	64.86	66.42	71.41
strawberry	peel	43.08	72.38	40.00
tomato	flesh	53.68	57.67	39.24
	peel	37.27	69.19	42.51

stalk	18.19	23.13	123.32

Underlying factors of product expectations for fruit juice packages

To reveal underlying factors of product expectations, we first examined interrelationships between each semantic scales used in the experiment. The results show high correlation between scales "colour harmony", "preference", "naturalness" and "product quality", with correlation coefficients (R) all greater than 0.9.

We also found freshness to be highly correlated (0.9>R>0.7) with the other four scales. As shown in Figure 6, several data points located in the second quadrant of the plots of freshness against the other four scales, which means that although some package colour designs are colour-disharmonised, they were expected as a fresh juice product. These results indicate unique contribution of freshness to observers' expectation of fruit juice product.

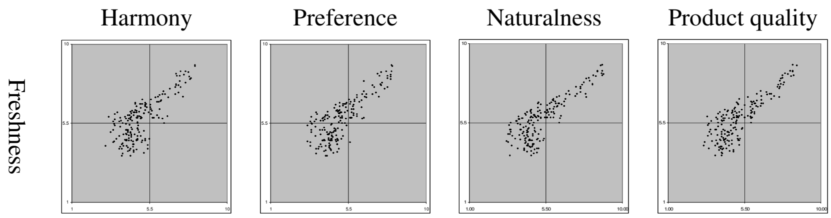


Figure 6. The relationships of freshness against the other 4 scales.

Factor analysis was conducted to explore underlying factors of the five scales. These results reveal 2 principal factors. The first factor, Product Preference, synthesised the scales of colour harmony, preference, naturalness and the product quality. This factor represents how harmonious the colour scheme of a package design is and how natural and quality the product appears. The second factor, Freshness, uniquely represented the freshness scale. This factor simply represents how fresh a juice product may appear. Note that although the factor analysis was able to identify two factors, these two factors were actually closely correlated, as suggested in Figure 6. The two factors represent two main aspects of observers' product expectations in terms of preference and freshness.

General effects of package colour and fruit image on product expectations

To see how different package colours influenced the observers' product expectations, we plotted factor scores for the two factors extracted, i.e. Product Preference and Freshness, against each package colour in terms of lightness (L*), chroma (C*) and ΔEx, where ΔEx represents colour difference between a package colour and a specific reference colour x.

The results were shown in Figures 7 (a)-(f). For both factors, L* of package colours were found to have low correlation with the two factors (R < 0.32). However, a fairly high correlation was found between package colour's chroma (C*) and both factors (R = 0.45 for product preference and 0.58 for freshness). This suggests that the observers tended to prefer juice products with colourful package colours to those with greyish colours.

When we replaced C* with ΔEx in the diagram, we found the trend to be clearer in terms of the relationships of ΔEx against Product Preference and Freshness, as shown in Figures 7 (c) and (f), respectively. The correlation coefficients were found to be 0.67 for Product Preference with the reference colour x at (L*, a*, b*) = (60, 20, -14), and 0.67 for Freshness with the reference colour x at (L*, a*, b*) = (36, 17, -0.5). This suggests that these two reference colours would elicit the worst responses in terms of Product Preference and Freshness. The larger the colour difference between a package colour and each reference colour, the higher expectations for freshness and preference will be elicited.

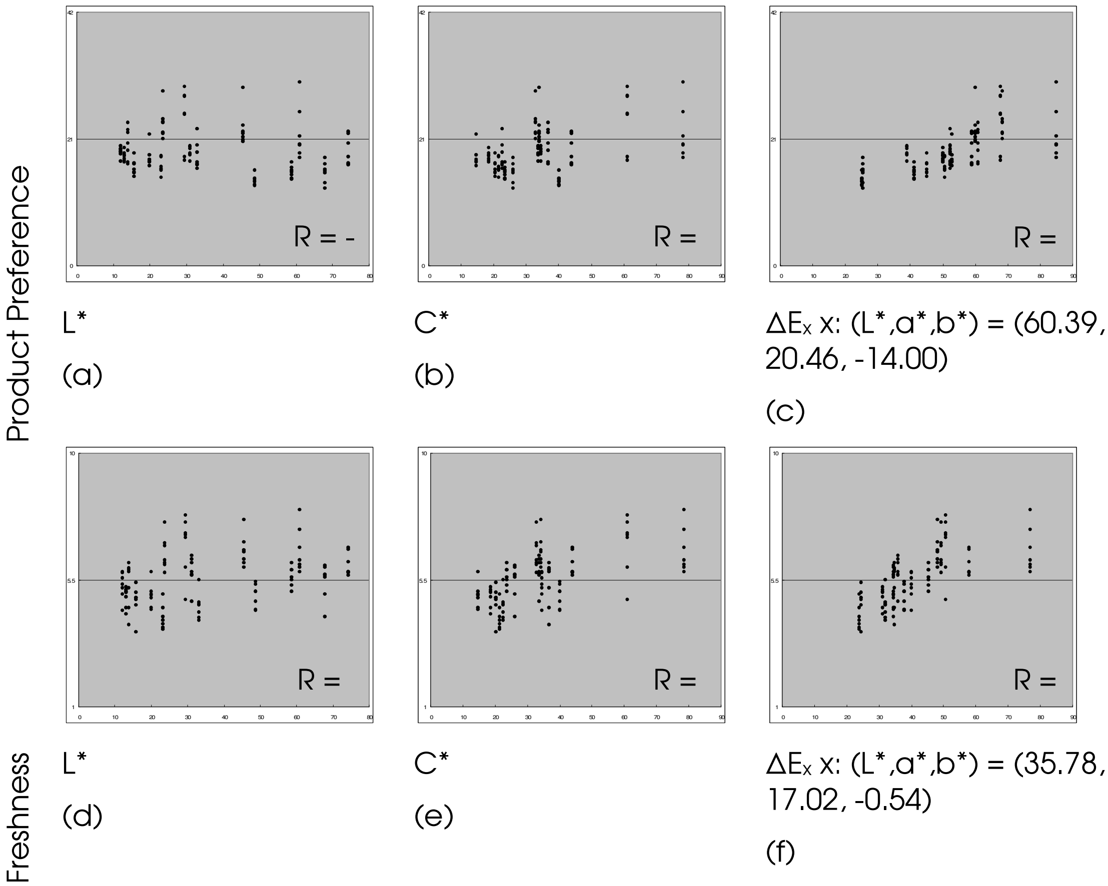


Figure 7. Factor scores of Product Preference and Freshness plotted against lightness (L*) and chroma (C*) of package colours, and against colour difference between package colour and a reference colour (ΔEx)

The same method was used to examine the relationships of factor scores for Product Preference and Freshness with the colour difference between package colour and fruit colour in terms of lightness difference (ΔL*), chroma difference (ΔC*) and hue difference (Δh).

As a result, the correlation between the factor scores and ΔL* were found to be low, with a correlation coefficient of -0.06 for Product Preference and -0.32 for Freshness. For ΔC*, on the other hand, the correlation coefficients were -0.39 for Product Preference and -0.43 for Freshness, respectively, suggesting that the observers tended to prefer a product with small chroma contrast between the package colour and the fruit image colour. Figures 8 (a-b, d-e) illustrate these results.

With regard to hue, the relationships between Δh and the factor scores were found to show a wave-shaped pattern, as shown in Figures 8 (c) and (f). The diagrams suggest that the observers tended to prefer a product if the package colour and the fruit colour were identical or similar in terms of hue. When Δh ≈ 180°, i.e. cos(Δh) ≈ -1, the diagrams show negative factor scores, meaning that the observers tended not to prefer a product if the package colour and the fruit colour were complementary in hue.

These results were found to agree well with the colour harmony model developed by Ou and Luo (13). Note that Ou-Luo's model was based on experimental data using flat colour patches as the stimuli, whereas the present visual stimuli were complex images of fruit juice packages. This suggests that this colour harmony model can serve as a measure of product preferences and freshness for fruit juice packages. However, further studies are needed to verify this.

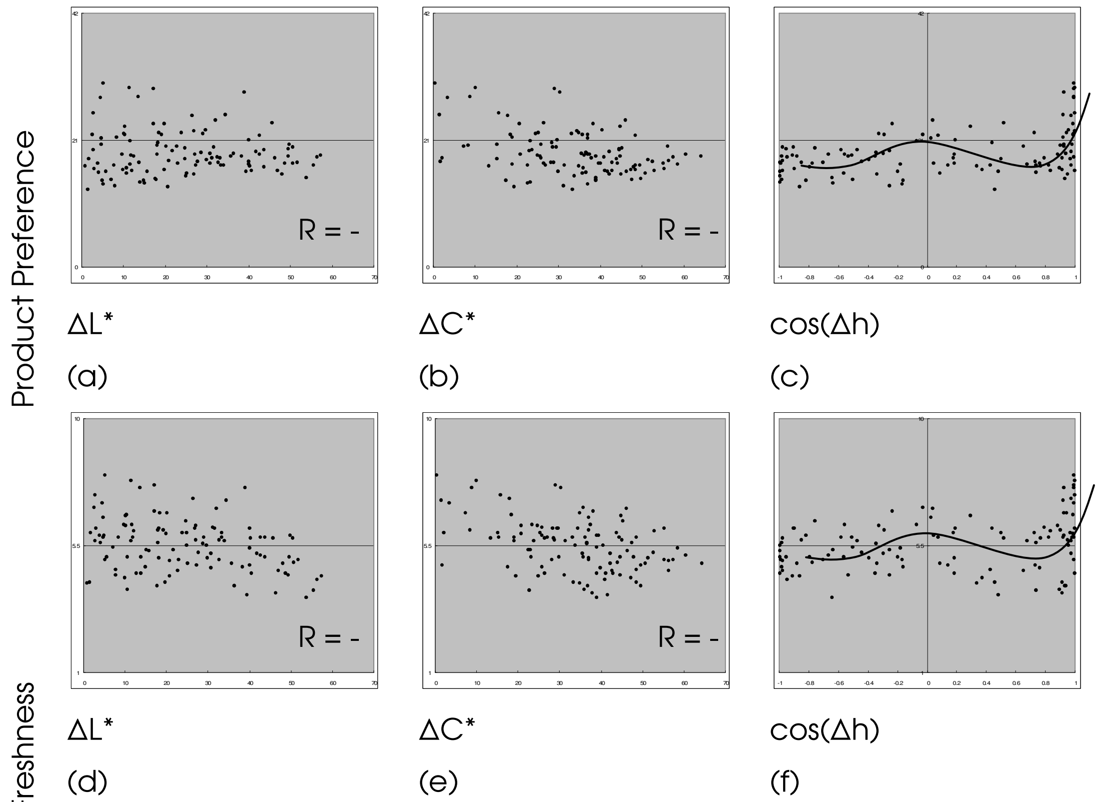


Figure 8. Factor scores of Product Preference and Freshness plotted against lightness difference (ΔL*), chroma difference (ΔC*) and cosine of hue difference (Δh) between package colours and fruit image colours

To summarise, there seemed to exist a reference package colour that had a connection with the poorest product expectations in terms of preference and freshness. As the package colour becomes further away from this reference colour in CIELAB space, observers' product expectations tended to get higher and higher. In addition, observers tended to prefer a product if the package colour and the fruit image colour were similar in chroma and hue.

Note, however, all the findings mentioned above do not show clear trends (R < 0.7). This indicates that there may be other factors that influenced the observers' product expectations. To investigate what these "other factors" were, we conducted the following analysis.

Effects of fruit classifications on product expectations

As mentioned above, there seemed to be trends that specific package colours and fruit image colours resulted in specific product expectations. However, such trends were found to be unconvincing. To reveal any other underlying factors, we divided the 7 fruits into 3 groups by their hue, and then conducted further data analysis for the two factors, Product Preference and Freshness. This resulted in 6 datasets (G1~G6), as shown in Table 3. Note that the reason why fruits were divided by hue is that packages with similar fruit colours and the same package colour elicited similar results. The factor analysis of Product Preference/Freshness of the 7 fruits was conducted and the results showed 3 groups of fruits.

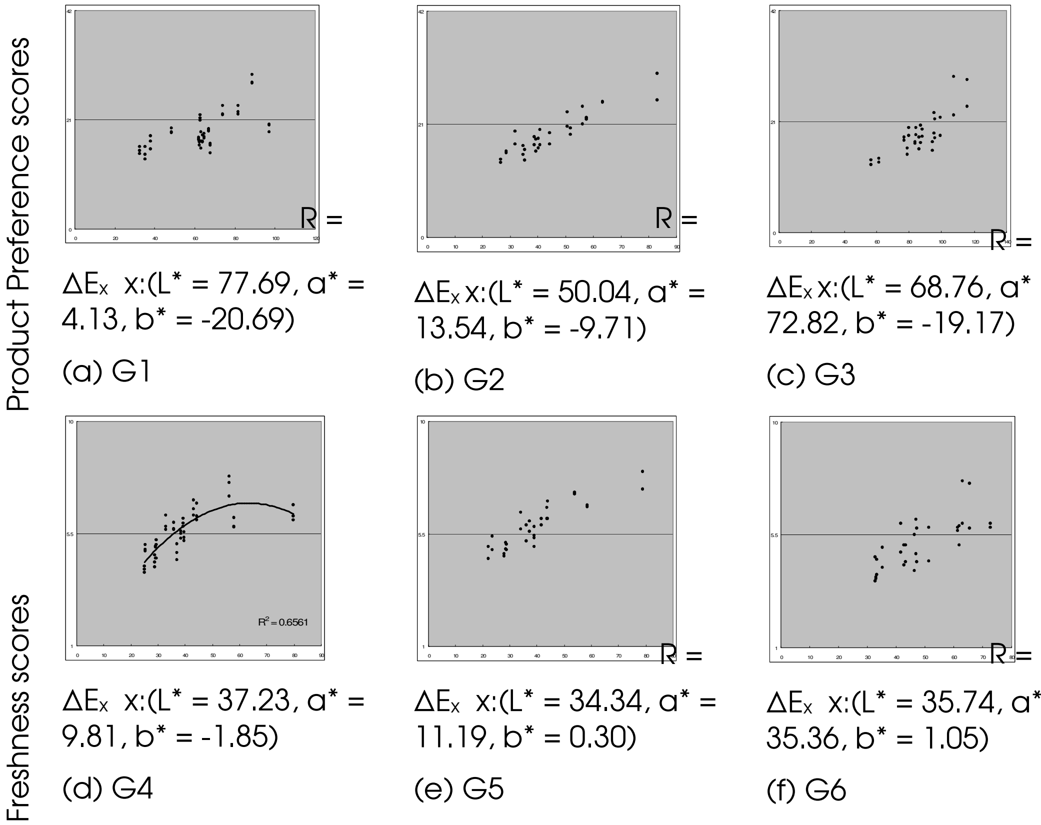
Table 3. The 6 groups of the relations between package colour scheme and consumers' emotional responses

Factors	Scales	Fruit group 1 (reds) Cranberry Strawberry Tomato	Fruit group 2 (orange/yellow) Orange Grapefruit	Fruit group 3 (yellow/green) Apple Pineapple
Product Preference	Colour harmony Preference Naturalness Product quality	G1	G2	G3
Freshness	Freshness	G4	G5	G6

Methods used in Section 1.3 were again used here to study effects of package colour on product expectations by looking into each of the 6 datasets. In particular, we used ΔEx, i.e. the colour deference between the package colour and a reference colour, as a measure to investigate such effects.

For Product Preference, the G1 dataset shows close correlation between the factor scores and ΔEx ($R = 0.67$) with a reference colour x at (L^*, a^*, b^*) = (78, 4, -21). The same approach was used for G2 and G3. The results show that for G2, these factor scores are highly correlated with ΔEx ($R = 0.92$) where the reference colour x is at (L^*, a^*, b^*) = (50, 14, -10). For G3, the correlation coefficient is 0.81 for a reference colour x at (L^*, a^*, b^*) = (69, 73, -19). These results are shown in Figures 9 (a) to (c).

The same analysis method was used for Freshness. The results show close correlation between ΔEx and the factor scores, with a correlation coefficient of 0.81 for G4, with a reference colour x at (L*, a*, b*) = (37, 10, -2), a correlation coefficient of 0.89 for G5, with a reference colour x at (L*, a*, b*) = (34, 11, 0) and a correlation coefficient of 0.73 for G6, with a reference colour x at (L*, a*, b*) = (36, 35, 1). The results are shown in Figures 9 (d) to (f).



ΔE_x x:(L* = 77.69, a* = 4.13, b* = -20.69)

(a) G1

ΔE_x x:(L* = 50.04, a* = 13.54, b* = -9.71)

(b) G2

ΔE_x x:(L* = 68.76, a* = 72.82, b* = -19.17)

(c) G3

ΔE_x x:(L* = 37.23, a* = 9.81, b* = -1.85)

(d) G4

ΔE_x x:(L* = 34.34, a* = 11.19, b* = 0.30)

(e) G5

ΔE_x x:(L* = 35.74, a* = 35.36, b* = 1.05)

(f) G6

Figure 9. Factor scores of Product Preference and Freshness plotted against colour difference between package colour and a reference colour (ΔEx) for various fruit groups

The result suggests that the larger the colour difference between a package colour and a reference colour, the higher expectations for freshness and preference will be elicited, and that the reference colour varies with hue of the fruit image colour (as the fruit images were classified into 3 groups by the fruit's hue).

The same method was used to examine the relationships of factor scores for Product Preference and Freshness with the colour difference between package colour and fruit image colour in terms of chroma difference (ΔC*). As illustrated in Figures 10 (a) to (c), G1 and G2 both show the following trend: the smaller the chroma difference is, the higher the factor score for Product Preference.

For Freshness, trends similar to G1 and G2 were found for G4 and G5: ΔC* was found to be negatively and closely correlated with factor scores of Freshness, with a correlation coefficient of -0.60 for G4 and -0.65 for G5. The results are shown in Figures 10 (d) to (f).

These results suggest that for G1, G2, G4 and G5, the chroma difference between package colour and fruit image colour has a strong link with product expectations. However, there was no such a link for G3 and G6. Note that the fruit groups for G1, G2, G4 and G5 have the following hues: red, orange and yellowish orange, and that those for G3 and G6 include green and yellow.

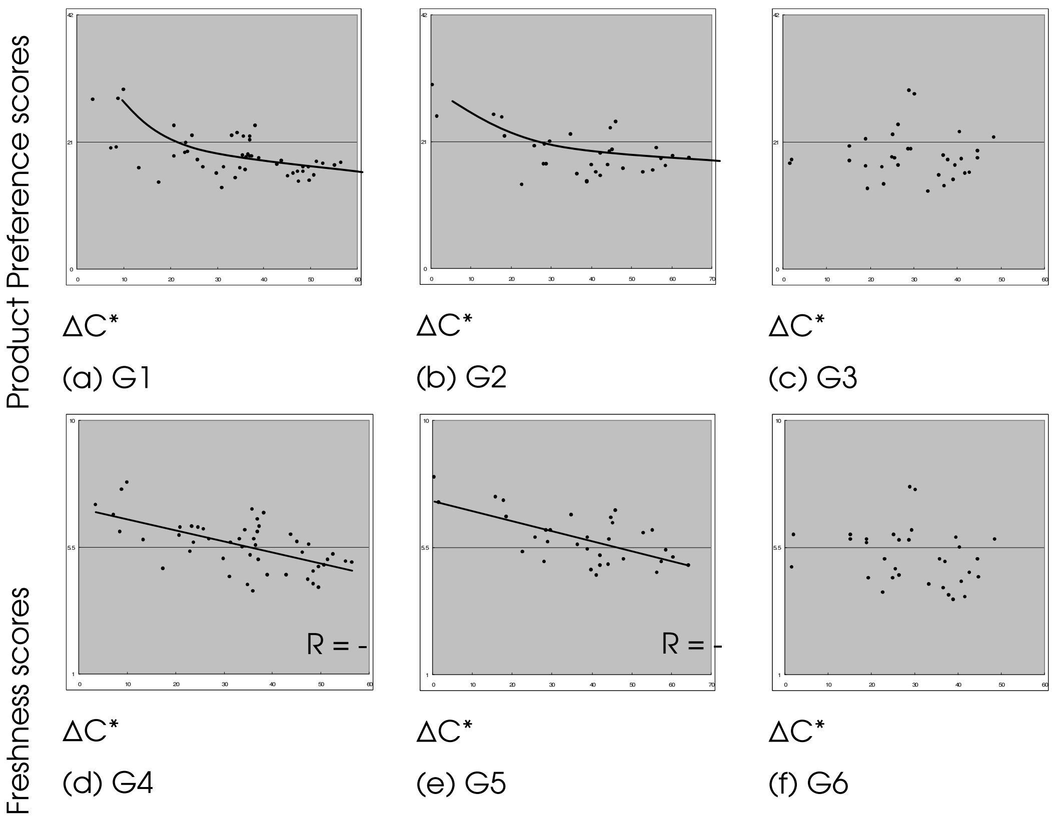


Figure 10. Factor scores of Product Preference and Freshness plotted against chroma difference (ΔC*) between package colours and fruit image colours for various fruit groups

Conclusions

The present study reveals 2 underlying factors in package colour design: Product Preference and Freshness. The 7 fruit images used in the experiment can be categorised by the hue of fruit colours into several subgroups; each subgroup represents a unique correlation between package colour and product expectations. To achieve a preferred and colour-harmonised package design, similarity in chroma and hue between package colour and fruit image colour are recommended.

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Shuo-Ting Wei

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