

The Relationship Between Visual Perceptions and Taste Expectations Using Food Colours

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ABSTRACT

This paper describes a modelling method for predicting consumer expectations using food colours. Orange juice was chosen as an example in this study to develop such a model. This model linked the relationships between juice colour and the expectations of sourness, sweetness, bitterness, flavour strength and freshness. The experimental results suggested that the relationships can be modelled by the concept of colour difference formula, for which CIELAB formula was modified for the purpose to relate visual and taste perceptions. The models are robust, explaining at least 72% of the data behaviour.

Keywords

Fruit juice, Expectations, Colour, Appearance, Colour tolerance

General Terms

Measurement, Performance, Experimentation, Human factors

1. INTRODUCTION

Colour appearance of food delivers the initial impression of the food itself to the customers. Customers' expectations of the food, such as flavour, tastes and quality, are then evoked from visual perception. These expectations play a vital role in making decisions of purchasing [1]. This is why seeking an appropriate food colour and controlling colours are always the major tasks in food industry.

For decades, researchers seek to link food colour and sensory characteristics either in the perceived levels or expected levels [2-8]. In general, they suggested that vivid colours tended to arouse stronger tastes or flavours than pale colours. People tended to prefer the liquid colours that matched with their memory (e.g. cranberry juice drink with vivid red colours). However, few of these studies proposed a full view of the relationship between colours and sensory characteristics for a specific liquid food. Such a view would comprise a map of the intensity of sensory characteristics plotted on a colour space such as CIELAB (see [9-11]). With such a map, one can illustrate how intensity varies with changes of location in colour space. This study is aimed to use the map to model the relationships between liquid colours and the intensity of sensory characteristics in the expected levels.

2. METHOD

The aim of this study was achieved by conducting an experiment using semantic differential on a colour-calibrated CRT monitor. Fifteen participants, seven males and eight females, aged from 22 to 36 years with an average of 25, were asked to visually assess stimuli shown on the display and to provide their psychological responses using the bipolar scales of sourness (Not sour at all – Extremely sour), sweetness (Not sweet at all – Extremely sweet), bitterness (Not bitter at all – Extremely bitter), flavour strength (Weak – Strong) and freshness (Stale – Fresh). Each of these scales was presented in terms of seven categories.



Figure 1. The experimental stimulus on the right was designed according to the existing juice product on the left.

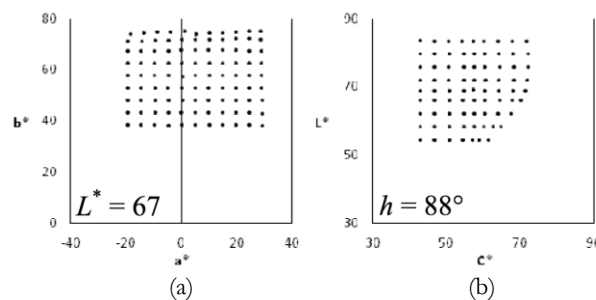


Figure 2. The 174 selected juice colours: (a) the 98 equal-luminance juice colours; (b) the 76 equal-hue juice colours.

A total of 174 stimuli were assessed by the participants. They were designed according to an image of an existing juice product. As shown in Figure 1, the bottle on the left shows the existing juice product and the image on the right shows an example of the stimuli. The layout of all stimuli was identical except juice colours. As shown in Figure 2(a), the 174 juice colours were systematically selected in CIELAB colour space. Among these 98 were selected along the axes of a^* (redness-greenness) and b^* (yellowness-blueness) on the a^* - b^* plane every 5 units from the initial juice colour, which had values of L^* , C^* and h equal to 69, 56 and 89° , respectively. This initial juice colour was determined by measuring some orange juices using a

colour measuring instrument in a viewing cabinet. The ranges of colour rendering were determined in a pilot study involving manipulation of the colour on the monitor screen until the image no longer looked like orange juice. The same approach was also used to select the other 76 juice colours along the axes of L^* (lightness) and C^* (chroma) on the L^*-C^* plane (see Figure 2(b)).

3. RESULTS

The consistency of behavioural data was examined via the tests of inter-observer and intra-observer agreements. As a result, the difference between individual observers' responses and the responses of the majority (i.e. mean scores) was smaller than 1.5 categories on the basis of the 7-category measurement scale. The difference between repeated assessments was smaller than 1 category. The results showed a high level of observer consistency and the data were valid for further analysis.

According to the examination of the relationships between colour attributes and the behavioural data, we found that the intensities of the five expectations varied in accordance with the changes of colour perceptions. Taking sweetness for example as shown in Figure 3, its intensities varied mainly with chroma ($R = 0.81$) and hue ($R = -0.83$). A colourful orange juice with a hue angle around 70° appeared sweetest comparing with the other colours studied. The changes for lightness did not vary the perception of sweetness ($R = 0.01$). For the other four expectations, greenish juice colours elicited greater sourness and bitterness responses. Darker juice colours were more likely to be expected to be bitter, and redder and yellower juice colours were expected to have stronger flavour. Fresher juices were located in the region of saturated yellow.

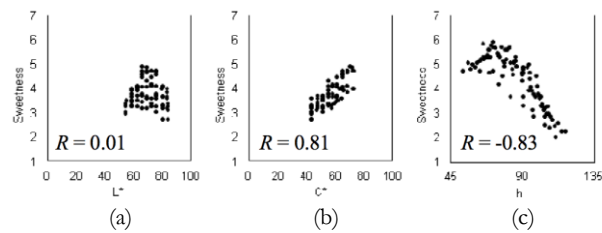


Figure 3. The scatter plots of sweetness against the three colour attributes: (a) lightness, (b) chroma and (c) hue angle.

The above results suggest that each taste expectation can be modelled as a function of colour attributes. After trials on various models, a simple metric based on colour difference equation can explain well the relationship between the taste expectation and colour attributes, i.e. the change of taste expectation against a colour centre in CIELAB colour space. As shown in Figure 4, the intensity of sweetness gradually increases toward a colour centre. This feature of the relationship between juice colour and expectations was modelled using the formula ΔE_{OJ} (Eq. 1), which is a modification of CIELAB colour difference formula.

$$\Delta E_{OJ} = \sqrt{(L^* - L_0^*)^2 + \frac{(C^* - C_0^*)^2}{k_c} + \frac{\Delta H^2}{k_h}} \quad (\text{Eq.1})$$

where $\Delta H^2 = 2\sqrt{C^* \cdot C_0^*} \cdot \sin\left(\frac{h-h_0}{2}\right)$

and L^* , C^* and h are CIELAB colour attributes of a given colour; L_0^* , C_0^* and h_0 are CIELAB colour attributes of the colour centre; k_c and k_h are two coefficients.

Table 1 summarises the values of parameters of ΔE_{OJ} for each of the five expectations. The corresponding predictive performance (i.e. R^2) is also given in the table. Overall, ΔE_{OJ} explains over 80% of the experimental data except for sourness (72%).

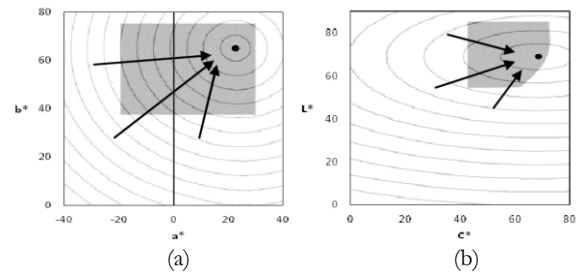


Figure 4. The contour map of sweetness in (a) a^*-b^* plane and in (b) L^*-C^* plane. Gray areas represent the range of juice colours being examined in this study. The arrows represent the directions of intensity increase.

Table 1. CIELAB values of colour centres associated with the five expectations. The values of R^2 represent the performance of ΔE_{OJ} for explaining the experimental results.

Colour centre	L_0^*	a_0^*	b_0^*	C_0^*	h_0	k_c	k_h	R^2
Sourness	74	21	54	58	69	0.03	0.01	0.72
Sweetness	69	23	66	69	71	3.59	3.88	0.86
Bitterness	83	19	62	65	73	2.01	1.00	0.80
Flavour strength	89	-33	10	34	163	1.21	1.16	0.83
Freshness	68	8	66	66	83	4.39	3.54	0.82

4. ACKNOWLEDGEMENT

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