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Color Changes in Clarified Fruit and Vegetable Juices by Mixing Ratios

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Abstract

Clarified fruit and vegetable juices (apple, carrot and tangerine) were produced using ultrafiltration and their color changes due to the mixing ratio were evaluated. Clarification was carried out by passing the supernatant of extracted juice through a filter and also by using a membrane of molecular weight cut-off 10,000 Daltons to obtain the juice ultrafiltrates. The mixing ratio between apple and carrot juices was kept constant at 1:1 while increasing the amount of tangerine juice according to 10, 20, 30, 40 and 50% and stored at 4°C prior to the color measurement. Hue angle (h_{ab}) and L*-value increased as the tangerine mixing ratio increased. The color difference indicated by ΔE-value also increased as the amount of tangerine increased indicating that the color of the mixed juice became pale and the changes were slight but distinctive. On the other hand, chroma (C*), a*- and b*-values decreased as the tangerine mixing ratio increased indicating that the color of the mixed juice became slightly more grayish and the samples were becoming less yellow. A simple mathematical model to predict each color characteristic is proposed.

Key words: color, juice, ultrafiltration, mixing ratio

INTRODUCTION

Ultrafiltration (UF) offers an efficient and reliable means to clarify noncloud-type fruit and vegetable juices. The hydrostatic pressure differences are the driving forces in such a membrane separation process (1) and the permeate produced will contain low molecular weight components smaller than the membrane pores used. In comparison to the conventional clarification process such as plate and frame and vacuum drum filtration, UF can be a simpler, energy efficient and cost effective method for apple juice clarification (2). Other advantages are the minimization of the loss of distinctive flavors and nutrients of fruit and vegetables during the process.

Recently the drink market in Korea has changed towards high quality processed foods and consumers demand new types of beverages. The growth of carbonated beverage consumption has slowed down while the growing categories of beverages are isotonic or sports drinks as well as noncarbonated fruit and vegetable juices (3). A number of investigations related to UF applications in fruit and vegetable juice processing (4-12) have been reported. However, studies on the color characteristics of clarified juice using ultrafiltration are still limited and application on the blended fruit and vegetable juices is scarce.

Our objectives were to produce clarified fruit and vegetable juices (apple, carrot and tangerine) using UF, to evaluate the color changes due to the mixing ratio, and to propose simple prediction models for predicting the color parameters.

MATERIALS AND METHODS

Sample preparation

Fresh apples, carrots and tangerines were obtained from the local market in 20 kg lots and stored at 4°C until further processing for less than 2 weeks. Each sample was washed with tap water and sorted. Decayed fruit was discarded. Carrot samples were blanched for 30 s in 80°C water and cooled in cold water. Each sample was then ground using a juice mixer (Angel, Hosan Manufacturing Co., Korea) to extract juice. Ascorbic acid (2 g per 1 L sample) was added to each extracted juice to prevent color degradation. Each extracted juice was then centrifuged (4°C, 10,000 rpm, 15 min) and the supernatant was filtered to remove remaining solid particles using an AP25 filter (Millipore Corp., Bedford, USA).

Ultrafiltration

A plate-type ultrafiltration system (Minitan™ II, Millipore Corp., Bedford, USA) was used to remove suspended solids in the juice. It consisted of a stainless steel frame, lower and upper acrylic manifolds, stainless steel adapter, and two pressure gages. Four low binding regenerated cellulose UF membranes with a nominal molecular weight cutoff (MWCO) point of 10,000 Daltons were used. A peristaltic pump (MasterFlex L/STM, Model No. 7523-20, Barnant Co., Barrington, USA) was used to sustain the pressure in the system. The system was operated at an average transmembrane pressure of 150 kPa and a sample temperature of 25°C. Juice samples were processed at a 9:1 concentration ratio in a continuous mode.

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Mixing

Each juice was prepared and stored at 4°C before mixing within a day. When each sample was ready, mixing was done at appropriate ratios using a Vortex mixer. The mixing ratio between apple and carrot was kept constant at 1:1 while increasing the amount of tangerine from 0 to 50% and stored at 4°C prior to color measurements.

Color measurements

Color parameters were measured using a Minolta Chroma Meter 210 (Minolta Camera Co., Ltd., Osaka, Japan) using the CIE 1976 Chromameter L*a*b* color scale equipped with a standard C illuminant using a 0° illumination angle and a 0° viewing angle. Samples were presented in 2 mm thick glass cuvettes, and calibration was done with distilled water. The reported color parameters are the mean values of three observations.

Statistical analysis

The regression analysis program (13) was used to develop a mathematical model that could be used to predict the color parameters of juice ultrafiltrates depending upon the mixing ratio.

RESULTS AND DISCUSSION

Color characteristics of single juice permeate

Color characteristics of each juice permeate are given in Table 1. The L*-value, indicative of the lightness of the sample, of apple permeate showed the highest value of 99.77 while the lowest value was obtained with carrot permeate. The a*-value, indicative of the greenness of the sample with negative values, of the tangerine permeate showed the lowest value of 0.41. The positive b*-values indicate the yellowness of the sample. The carrot permeate had a b*-value of 2.10, which shows the prominence of the yellow color among samples. The value of chroma (C*) in L*C*h color space is 0 at the center and increases according to the distance from the center. Hue angle (h_{ab}) is defined as starting at the +a* axis and is expressed in degrees. The highest C*-value of 2.15 was obtained with the carrot permeate while the highest h_{ab}-value of 109.80 was obtained with the tangerine permeate.

Table 1. Color characteristics of single juice permeate

Sample	L*	a*	b*	C*	h_{ab}
Apple	99.77	-0.14	0.78	0.79	100.10
Carrot	98.89	-0.16	2.10	2.15	102.43
Tangerine	99.71	-0.41	1.12	1.19	109.80

Effect of mixing ratios

The effect of the mixing ratios on the color parameters is shown in Fig. 1. The L*-value increased from 99.30 to 99.53 as the tangerine amount increased from 0 to 50% in the mixed permeate. Apparently, the mixed permeate without tangerine (i.e., apple and carrot permeate with 1:1 mixing ratio) showed the lightness value between respective values of apple and carrot. The color difference (ΔE) and h_{ab}-value linearly increased

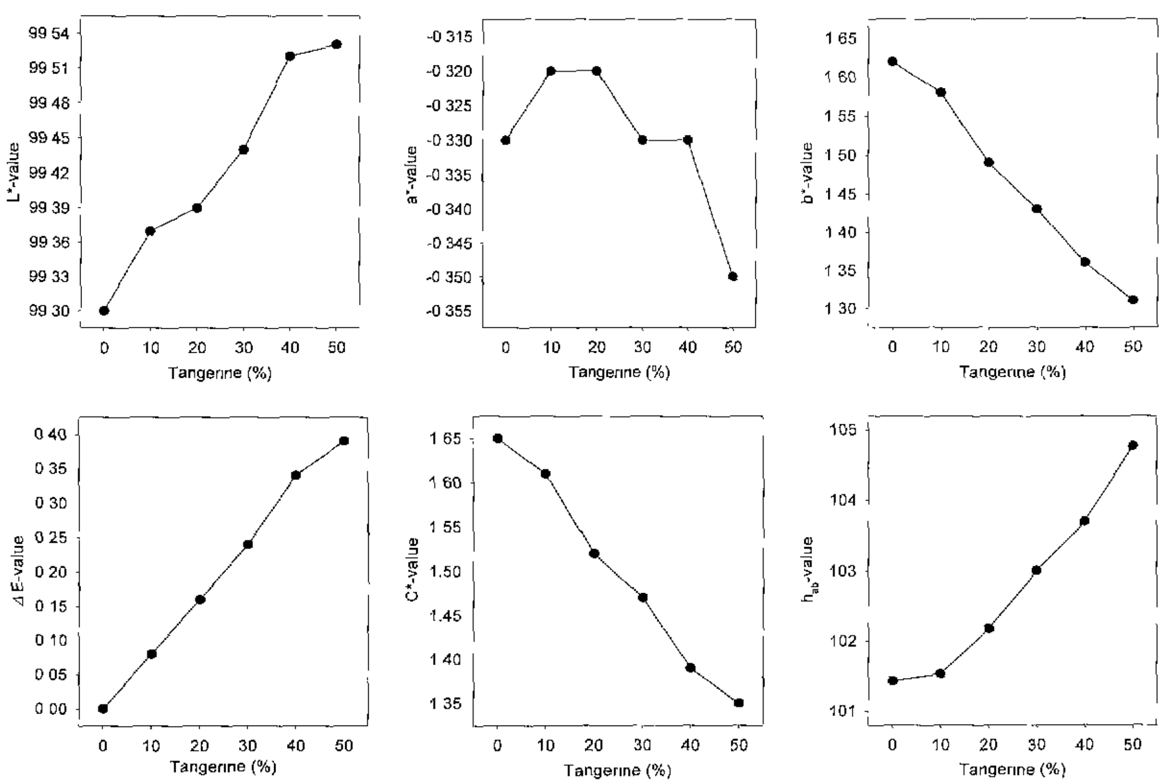

Fig. 1. Color characteristics of blend juice permeate as influenced by tangerine added.

Table 2. Simple prediction models of the mean color characteristics of juice permeate

Color parameters	Model[1)]	Regression coefficient			(r^2)[2)]
		b_0	b_1	b_2	
L*	Model 1	99.307	0.0047	-	0.9687***
	Model 2	99.304	0.0053	-0.0000107	0.9698**
a*	Model 1	-0.323	-0.00035	-	0.5837^{NS}
	Model 2	-0.328	0.00054	-0.0000179	0.9036*
b*	Model 1	1.627	-0.0065	-	0.9921***
	Model 2	1.629	-0.0068	0.0000059	0.9923***
C*	Model 1	1.656	-0.0063	-	0.9909***
	Model 2	1.658	-0.0066	0.0000066	0.9911***
h_{ab}	Model 1	101.050	0.0687	-	0.9588***
	Model 2	101.353	0.0232	0.0009090	0.9946***

[1)]Model 1: $Y = b_0+b_1X$, Model 2: $Y = b_0+b_1X+b_2X^2$ where, Y = color parameter and X = amount of tangerine added in %, respectively
[2)]Significant at *5% level, **1% level, ***0.1% level, ^{NS}non-significant

as the amount of tangerine increased in the permeate mix. It indicated that the color of the mix became pale and the change was slight but distinctive.

On the other hand, the a*-value decreased from 0.32 to 0.35 as the tangerine mixing ratio increased indicating that the mixed juice became slightly more grayish with high amounts of tangerine. The b*- and C*-value also decreased linearly from 1.62 to 1.31 and 1.65 to 1.35, respectively indicating the samples were becoming less yellow.

Simple prediction model

The simple regression analysis was used to develop equations that could be used to predict the mean color parameters of blend permeate depending on the amount of tangerine added. The regression coefficients and r^2-values are summarized in Table 2. The significant r^2-values indicated that the prediction models fitted well with the experimental data. Although variations of each color parameters were slight but showed a direct relationship with the amount of tangerine added in the blend permeate.

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