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Color Characteristics of Concentrated Single and Blend Juices as Influenced by Concentration Methods

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Abstract: Clarified apple, carrot and orange juices were prepared using ultrafiltration and their single and blend juices were further concentrated using ultrafiltration, freeze-drying and rotary evaporation. Effect of concentration methods on the color of concentrated single and blend juices was investigated. The color properties of concentrated single and blend juices showed that heat concentrated samples using rotary evaporator had significantly lower L*-values than those of the other concentration methods regardless of juice type (i.e., apple, orange or carrot) and blending ($p<0.05$). The a*-values of heat concentrate juices were lower and b* values were higher than those prepared by UF and vacuum freezing in general. Concentrated carrot or carrot rich juices showed equal or relatively higher L*-values, while concentrated apple or apple rich juices showed equal or lower L*-values than those of the other single and blend juices regardless of concentration methods. Concentrated carrot or carrot rich juices showed relatively lower b*-values in general, while concentrated apple or apple rich juices showed higher b*-values than those of the other single and blend juices in UF and vacuum-freeze concentration.

Key words: Color, concentration methods, single, blend juices

INTRODUCTION

Fruits and vegetables are containing various types of minerals, vitamins and other beneficial components for human health which are generally known as antioxidants. And they have been favored by consumers because of their distinctive flavor and fresh tastes[1]. Since it is expensive to package and store single strength juice, it is desirable to remove a part or all of the water from juice[2]. In particular, concentration reduces the storage volumes (so reducing transport and storage costs) and facilitates the preservation which is achieved by the improved shelf-life with increasing relative solids concentration. Unfortunately during the industrial transformation, a large part of the characteristics determining the quality of the fresh product undergoes a remarkable modification: the thermal damage and the chemical oxidation degrade more sensitive components reducing the quality of the final product[3-5]. In addition, disintegration of color pigment and browning reaction could be another detrimental fact[3,5].

Concentration processes avoiding high temperature are interesting approaches to preserve the nutritional and organoleptic characteristics of fruit and vegetable juices. Ultrafiltration (UF)[5-7], Reverse Osmosis (RO)[2,3,8] and freezing[9] can be used to successfully concentrate juice without thermal treatment. The objective of this study is to produce concentrated single and blended fruit and vegetable juices with the ratio of 1:1:2, 1:2:1 and 2:1:1 (apple:orange:carrot) and investigate the color characteristics of juices concentrated by different methods including ultrafiltration, vacuum-freeze and evaporation[9,10].

MATERIALS AND METHODS

Preparation of juice samples: Fresh apples (Busa variety), carrots and oranges were obtained from a local market in 20 kg lots and stored at 4° for less than 2 weeks until further processing. Each sample was washed with tap water and sorted for decayed ones. Carrot samples were blanched for 30 s in 80° water and cooled in cold water. Each sample was then ground using a juice extractor (Model DO-9001, Donga-osca Co., Korea) to extract juice. Each extracted sample was then filtered with 200 mesh nylon cloth to remove remaining solid particles. To produce blend juice concentrates, each filtered sample was blended prior to clarification using UF (Fig. 1). Ascorbic acid (2 g per 1 L sample) was added to prevent color degradation.

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Table 1: Concentration methods used in this study

	Concentration methods		
Conditions	Evaporation	Vacuum-freezing	Ultrafiltration
Speed	60 rpm	-	-
Temperature	70°	-50°	25°
Pressure	-	5~10 mmHg	100 kPa

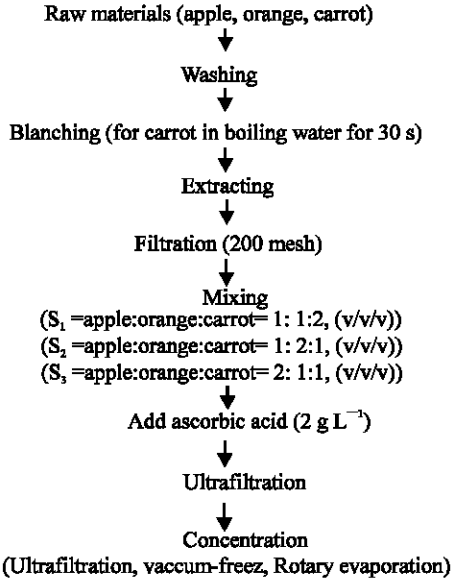

Fig. 1: Preparation procedure of concentrated mixed fruit and vegetable juices

Clarification and concentration: Prior to the production of concentrated juice, each clarified juice was first produced using a plate-type ultrafiltration system (Minitan™ II, Millipore Corp., Bedford, USA). Four high flux biomax polysulfone membranes with a nominal Molecular Weight Cutoff (MWCO) point of 50,000 Daltons were used. A peristaltic pump (Model 7523-20, Barnant Co., USA) was used to sustain the pressure in the system. The system was operated at an Average Transmembrane Pressure (ATP) of 100 kPa and 25°. Each clarified sample was then concentrated using several methods including rotary evaporation, vacuum-freeze and ultrafiltration. The rotary evaporator was operated at 60 rpm and 70° while vacuum-freeze concentration was done at-50° and 5~10 mmHg after prefreezing of sample at-35~-40° (Table 1). The ultrafiltration system was operated at 100 kPa and 25° in a continuous mode. All samples were concentrated to 70% of the initial volume.

Color measurements: Color parameters were measured using a Chroma Meter (Model CR-200, Minolta Co., Japan). Samples were placed in a 2 mm thick glass cuvettes and calibration was done with distilled water. L*, a* and b* values were measured in triplicate and the mean values were reported.

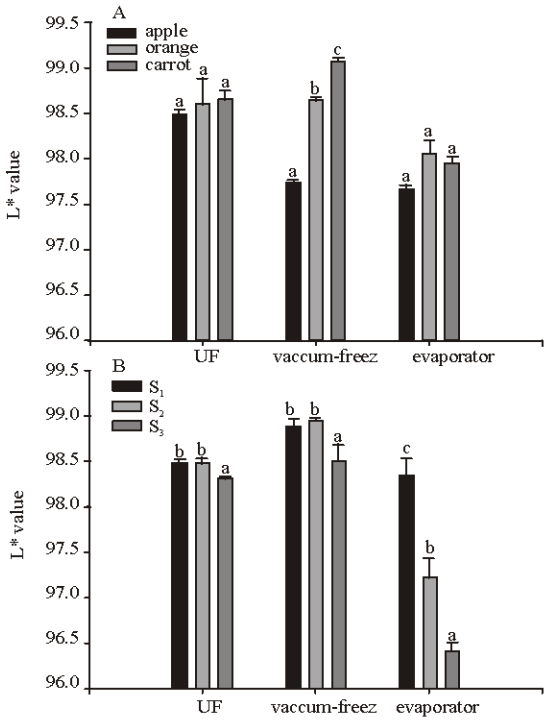

Fig. 2: L*-values of concentrated single and blend juices as influenced by concentration methods. Means within a treatment with the same letter are not significantly different ($p<0.05$). S_1: apple: orange : carrot = 1: 1: 2 (v/v/v), S_2: apple: orange: carrot = 1: 2: 1 (v/v/v), S_3: apple: orange: carrot = 2: 1: 1 (v/v/v).

Statistical analysis: Duncan's multiple range test was used to compare the differences of means among treatment groups. Differences of each means were tested at 5% level of significance.

RESULTS AND DISCUSSION

The color properties of concentrated juice samples depending on the concentration methods are presented in Fig. 2-4. As expected, regardless of concentration methods, lightness (L*-value) of single and blended juices was reduced[3,8] after the concentration process, especially in the case of rotary evaporator concentrated S_3 sample, in that the amount of apple was high. Concentrated carrot samples (single and S_1 which has the higher amount of carrot) showed equal or relatively higher L*-values, while concentrated apple sample (single and S_3 which has a higher amount of apple) had the equal or

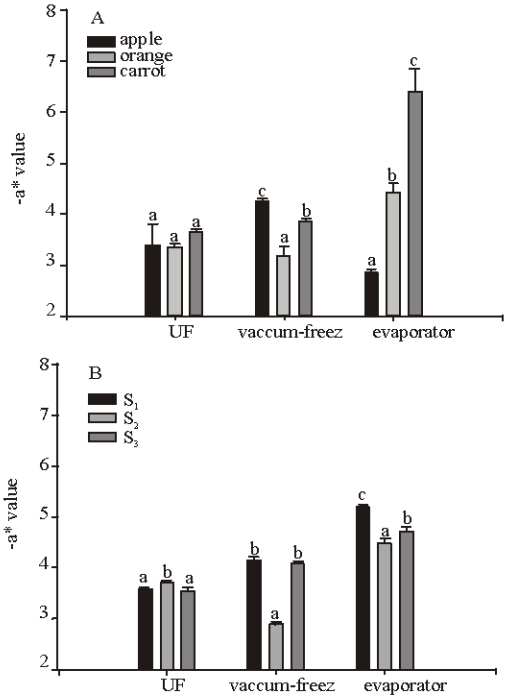

Fig. 3: a*-values of concentrated single and blend juices as influenced by concentration methods. Means within a treatment with the same letter are not significantly different ($p<0.05$). S_1: apple: orange : carrot = 1: 1: 2 (v/v/v), S_2: apple: orange : carrot = 1: 2: 1 (v/v/v), S_3: apple: orange: carrot = 2: 1: 1 (v/v/v)

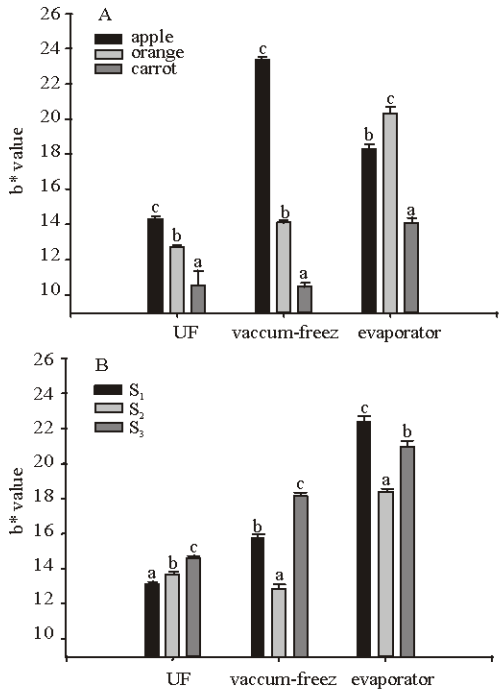

Fig. 4: b*-values of concentrated single and blend juices as influenced by concentration methods. Means within a treatment with the same letter are not significantly different ($p<0.05$). S_1: apple: orange: carrot = 1: 1: 2 (v/v/v), S_2: apple: orange : carrot = 1: 2: 1 (v/v/v), S_3: apple: orange: carrot = 2: 1: 1 (v/v/v)

lower L*-values than those of the other single and blend juices regardless of concentration methods. These distinctive findings are well observed in the single juices using vacuum-freeze concentration (Fig. 2A) and blend juices (Fig. 2B) using rotary evaporator.

It was also noted that L*-values of the both single and blend juices prepared using UF or vacuum-freeze were higher than those of samples prepared using rotary evaporator. This is due to the fact that heat was introduced to the samples during concentration using rotary evaporator and resulted in decreased L*-values. These are good agreement with previous report[5] which also showed significantly higher values for turbidity in heat concentrated samples than those of juices prepared by UF and vacuum-freeze.

Redness (a*-value) changed little regardless of raw material, blend ratio and concentration method (Fig. 3). The effect of the raw material on the a*-values within samples prepared by ultrafiltration and vacuum-freeze concentration methods was not clear except for single juices prepared using rotary evaporator (Fig. 3A). In that carrot samples showed the lowest a*-values while apple samples showed the highest a*-values. The heat induced effect on the a*-values was also observed both for single and blend juices except for apple juices prepared using rotary evaporator.

Yellowness (b*-value) as influenced by concentration methods both for concentrated single and blend juice samples is shown in Fig. 4. Concentrated apple samples showed the highest b*-values followed by concentrated orange and carrot samples within samples prepared by ultrafiltration and vacuum-freeze concentration methods. Again, the color characteristics of single juice concentrate and the effect of concentration method carried on to blend juice concentrate samples. For example, S_1 (apple:orange:carrot = 1:1:2 (v/v/v) containing high amount of carrot showed relatively lower b*-values while S_3 (apple:orange:carrot = 2:1:1 (v/v/v) containing high amount of apple showed higher b*-values than those of single and blend juices (Fig. 4B). This pattern is well observed in the samples prepared using vacuum-freezeand UF. The heat induced effect on the increase of b*-values was also observed both for single and blend concentrate samples except apple single juice concentrated using vacuum-freeze.

CONCLUSIONS

The color properties of concentrated single and blend juices showed heat concentrated samples using rotary evaporator had significantly lower L*-values (lightness) than those prepared by ultrafiltration and vacuum freezing regardless of juice type (i.e., apple, orange or carrot) and blending ($p<0.05$). These a*-values (redness) of heat concentrate juices were lower and b*-values (yellowness) were higher in general.

In terms of relationship between color and juice type and blending, concentrated carrot or carrot rich juices S_1 (apple:orange:carrot = 1:1:2 (v/v/v) showed equal or relatively higher L*-values, while concentrated apple or apple rich juices S_3 (apple:orange:carrot = 2:1:1 (v/v/v) showed equal or lower L*-values than those of the other single and blend juices regardless of concentration methods. Concentrated carrot or carrot rich juices showed relatively lower b*-values, while concentrated apple or apple rich juices showed higher b*-values than those of the other single and blend juices in UF and vacuum-freeze concentration.

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