

## Effect of Concentration Methods on the Quality of Single and Blended Juice Concentrates

Jun Ho Lee<sup>1\*</sup> and Kyoung Suck Sohn<sup>2</sup>

<sup>1</sup>Division of Food, Biological & Chemical Engineering, Daegu University, Gyeongsan, Gyeongbuk 712-714, Korea  
<sup>2</sup>R&D Institute, Chew Young Roo Co., Ltd., Paju, Gyeonggi 413-060, Korea

### 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 quality of concentrated single juices and juice blends was investigated. Turbidity values of samples concentrated by evaporation were significantly higher than those prepared by ultrafiltration and vacuum freezing regardless of juice source (i.e., apple, orange or carrot) or blending ( $p < 0.05$ ). The highest soluble solids contents were obtained for the samples concentrated by evaporation process. Concentrated apple juice contained significantly higher amount of vitamin C and soluble solids than concentrated orange and carrot juices regardless of concentration methods ( $p < 0.05$ ). For blended samples, no direct relationships between blend ratio and total amount of vitamin C were found; however, samples contained more apple juice showed the highest value of soluble solids regardless of concentration methods.

**Key words:** clarification, concentration, methods, single and blend juices

### INTRODUCTION

Fruits and vegetables contain high levels of minerals and vitamins and many consumers favor their distinctive flavor and fresh tastes (1). Recently, fruits and vegetable juice extracts have received much interests as functional foods for the prevention of some adult diseases (2). 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 (3). This concentration process reduces the volume of juice and improves the shelf-life of concentrated juice by increasing the relative solids concentration.

The concentration by heating has been widely used until recently because of its simplicity. However, there are several disadvantages of heat concentration: 1) disintegration of color pigments due to heat, 2) browning reaction, 3) nutrients loss, 4) volatile flavor loss due to evaporation, and 5) higher energy costs (4).

Other concentration methods such as ultrafiltration (UF), reverse osmosis (RO), and freeze-drying can be used to successfully concentrate juice. For example, freeze-drying can be applied without the major problems mentioned above in contrast to traditional evaporation techniques. This method typically produces high quality concentrated products in general. The moisture is removed by sublimation and final products have less thermal degradation

and flavor loss because the concentration is done at relatively low temperatures. Juice is sensitive to heat treatment and many of their components are unstable even at moderate temperatures (3).

A number of investigations comparing concentration processes using UF (5), RO (2,3,6), evaporation (7,8), and freezing (7) have been reported. Despite the previous studies, comparisons of those concentration methods in relation to single and blended juice concentrates are scarce. The objective of this study was to produce concentrated single and blended fruit and vegetable juices and compare the quality parameters of juices concentrated by different methods including evaporation concentration, vacuum-freeze concentration and ultrafiltration.

### 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°C for less than 2 weeks until further processing. All fruit were washed with tap water and sorted to remove any that were decayed. Carrots were blanched for 30 s in 80°C water and cooled in cold water. Each sample was then ground using a juice extractor (Model DO-9001, Donga-osca Co., Korea) to extract the juice. Each extracted sam-

\*Corresponding author. E-mail: leejun@daegu.ac.kr  
Phone: +82-53-850-6535, Fax: +82-53-850-6539

ple was then filtered through 200 mesh nylon cloth to remove remaining solid particles. Ascorbic acid (2 g per 1 L sample) was added to prevent color degradation. To produce blended juice concentrates, each filtered sample was blended prior to clarification using UF.

#### Clarification and concentration

Prior to the production of concentrated juice, each clarified juice was first produced using a plate-type ultrafiltration system (Minitan<sup>TM</sup> 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 at 25°C.

Each clarified sample was then concentrated using several methods including rotary evaporation, freeze-drying and ultrafiltration. The rotary evaporator was operated at 60 rpm and 70°C while, freeze-dry concentration was done at -50°C and 5~10 mmHg after prefreezing the samples at -35~-40°C. The ultrafiltration system was operated at 100 kPa and 25°C in a continuous mode. All samples were concentrated to 70% of the initial volume.

#### Density and pH measurements

Density of each sample was measured using pycnometer while pH was measured using a pH meter (Model 340, Mettler Delta Co., UK). Each measurement was done in triplicate and the mean values were reported.

#### Turbidity measurement

Turbidity was measured with a UV-visible spectrophotometer (Model UV-1201, Shimadzu Corp., Japan) at

660 nm (9). Mean values from triplicate measurements were reported.

#### Soluble solids and vitamin C measurements

Soluble solids were measured with a hand refractometer (Type N1, Atago Co., Japan). Ascorbic acid was determined by 2,4-dinitrophenylhydrazine titration method (10). Each measurement was done in triplicate and the mean values were reported.

#### 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  $\alpha=0.05$ .

## RESULTS AND DISCUSSION

#### Physico-chemical property

The physico-chemical properties of concentrated juice samples prepared by different concentration methods are summarized in Table 1 and 2. The pH of the single juice concentrates varied from 4.44~4.63, 3.49~3.95, and 5.53~5.57 for apple, orange, and carrot sample, respectively while pH of blended samples varied from 4.24 to 4.65 depending on the blend ratio and concentration method. pH values were significantly different depending on the raw material used as expected and were dependent on the concentration methods used. Similar results were found for blend juice samples; for example, S<sub>1</sub> samples had a significantly higher pH since the samples contained higher amount of carrot. Again, significant differences in pH values were found for blended juice samples, depending on the concentration methods used.

**Table 1.** pH of concentrated juice samples depending on the concentration methods

Concentration methods	Single			Blend		
	Apple	Orange	Carrot	S <sub>1</sub> *	S <sub>2</sub>	S <sub>3</sub>
UF	4.51 <sup>BB</sup>	3.49 <sup>AA</sup>	5.57 <sup>CC</sup>	4.58 <sup>CA</sup>	4.24 <sup>AA</sup>	4.53 <sup>BB</sup>
Vacuum-freeze	4.63 <sup>BC</sup>	3.95 <sup>AC</sup>	5.53 <sup>CB</sup>	4.65 <sup>CB</sup>	4.64 <sup>BC</sup>	4.50 <sup>AA</sup>
Evaporation	4.44 <sup>BA</sup>	3.91 <sup>AB</sup>	5.47 <sup>CA</sup>	4.60 <sup>CB</sup>	4.31 <sup>AB</sup>	4.55 <sup>BC</sup>

<sup>a-c</sup>Means in the same row within a sample type with the same letter are not significantly different ( $p<0.05$ ).

<sup>A-C</sup>Means in the same column within a treatment with the same letter are not significantly different ( $p<0.05$ ).

\*S<sub>1</sub>, apple : orange : carrot=1 : 1 : 2 (v/v/v); S<sub>2</sub>, apple : orange : carrot=1 : 2 : 1 (v/v/v); S<sub>3</sub>, apple : orange : carrot=2 : 1 : 1 (v/v/v).

**Table 2.** Density (g/mL) of concentrated juice samples depending on the concentration methods

Concentration methods	Single			Blend		
	Apple	Orange	Carrot	S <sub>1</sub> *	S <sub>2</sub>	S <sub>3</sub>
UF	1.095 <sup>CA</sup>	1.082 <sup>BA</sup>	1.043 <sup>AA</sup>	1.083 <sup>CA</sup>	1.054 <sup>AA</sup>	1.080 <sup>BA</sup>
Vacuum-freeze	1.113 <sup>CB</sup>	1.098 <sup>BB</sup>	1.048 <sup>AB</sup>	1.092 <sup>BB</sup>	1.063 <sup>AB</sup>	1.094 <sup>BC</sup>
Evaporation	1.120 <sup>CC</sup>	1.107 <sup>BC</sup>	1.058 <sup>AC</sup>	1.106 <sup>CC</sup>	1.094 <sup>BC</sup>	1.081 <sup>AB</sup>

<sup>a-c</sup>Means in the same row within a sample type with the same letter are not significantly different ( $p<0.05$ ).

<sup>A-C</sup>Means in the same column within a treatment with the same letter are not significantly different ( $p<0.05$ ).

\*S<sub>1</sub>, apple : orange : carrot=1 : 1 : 2 (v/v/v); S<sub>2</sub>, apple : orange : carrot=1 : 2 : 1 (v/v/v); S<sub>3</sub>, apple : orange : carrot=2 : 1 : 1 (v/v/v).

Density values ranged from 1.043~1.120 g/mL and 1.054~1.106 g/mL for single and blend juice samples, respectively. Again, significantly different density values were obtained depending on the raw material as well as the concentration method used. The density of apple juice concentrates was significantly higher than that of orange juice followed by that of carrot juice, regardless of the concentration method used. In addition, samples concentrated by rotary evaporation showed significantly higher values of density regardless of sample type and blend ratio except for S<sub>3</sub>.

### Changes of turbidity

Effects of concentration methods on changes in turbidity for both single and blends are shown in Fig. 1. Heat concentrated samples using rotary evaporator showed significantly higher values for turbidity, regardless of fruit type (i.e., apple, orange or carrot) and blending, than those of samples prepared by UF and vacuum-freeze. This is due to the fact that concentration by UF and freeze-drying took place at relatively low temperatures, whereas the rotary evaporation process uses higher temperatures and might induce a thermal degradation, resulting in the higher

turbidity values. However, there was no distinctive pattern of changes in turbidity values for the different fruit juice samples or blends using the same concentration method. In other words, carrot juice concentrate followed by orange juice concentrate produced by UF showed the highest turbidity value while the lowest value was observed for carrot juice concentrated by freeze-drying. In general, the characteristic of single juice concentrate carried on to blend juice concentrate. For example, S<sub>1</sub> sample (apple : orange : carrot=1 : 1 : 2 (v/v/v)) concentrated using UF showed the highest turbidity value because it contained higher amounts of carrot. Similar findings were found for the S<sub>3</sub> sample concentrated using vacuum-freeze.

### Changes of soluble solids and vitamin C

Changes in soluble solids depending on the concentration methods, are presented in Fig. 2. The significantly higher soluble solids contents were obtained for the samples concentrated by rotary evaporation, regardless of juice type. This may be a consequence of components other than water being unable to pass through the membrane, resulting in the lower soluble solids contents in the samples concentrated using UF (11). Kim et al. (12) ex-

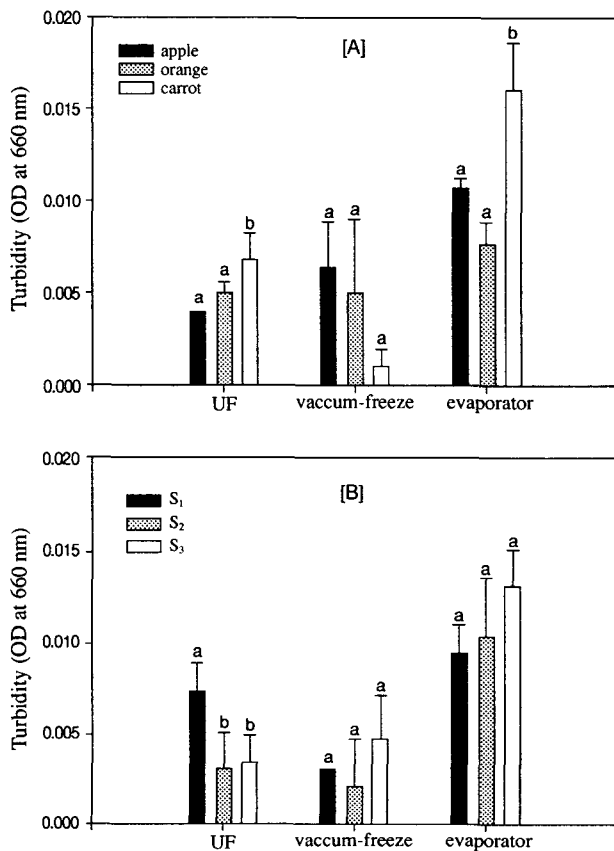


Fig. 1. Changes in turbidity depending on concentration methods (A: single juice samples, B: blend juice samples). Means within a treatment with the same letter are not significantly different ( $p < 0.05$ ).

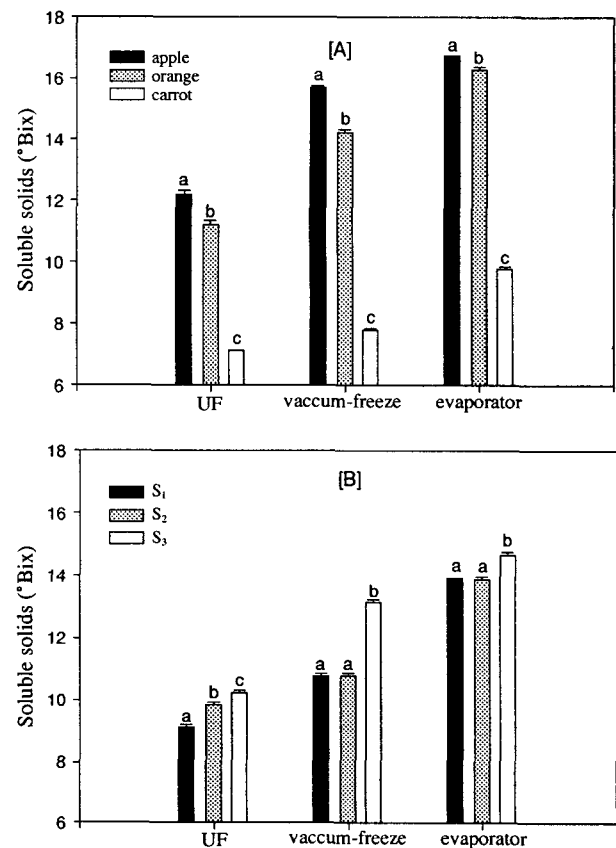


Fig. 2. Changes in soluble solids contents as affected by concentration methods (A: single juice samples, B: blend juice samples). Means within a treatment with the same letter are not significantly different ( $p < 0.05$ ).

plained that a portion of the soluble solids could be removed during the UF process, resulting in the lower values for soluble solids in a sample. In addition, apple juice concentrate followed by orange and carrot juice concentrates showed the significantly higher values of soluble solids regardless of the concentration methods used. Again, the characteristic of single juice concentrates carried through to the blended juice concentrates. For example, S<sub>3</sub> samples produced by each concentration method showed the significantly higher values for soluble solids since they contained more apple juice.

Effects of concentration methods on total vitamin C content are shown in Fig. 3. Samples concentrated using UF contained significantly higher amount of total vitamin C while heat concentrated juice samples using a rotary evaporator retained the least amount of total vitamin C, as expected ( $p < 0.05$ ). Similar results were reported by Lee and Seog-Lee (11) and Kim et al. (12), who reported higher vitamin loss in the samples treated with heat, as occurs during rotary evaporation. Concentrated apple juice contained significantly higher amount of total vitamin C regardless of concentration methods used ( $p < 0.05$ ). Each carrot juice concentrate contained the least amount of

total vitamin C. It is interesting to note that S<sub>3</sub> samples (apple : orange : carrot = 2 : 1 : 1 (v/v/v)) concentrated using UF and rotary evaporator had relatively lower amount of total vitamin C despite higher amount of apple juice. In general, destruction of vitamin C was less severe when the samples were concentrated using UF or vacuum-freezing since there was no phase change during the processes, unlike the rotary evaporation process.

## CONCLUSIONS

Heat concentrated samples using rotary evaporator showed significantly higher values of turbidity regardless of juice type (i.e., apple, orange or carrot) and blending ( $p < 0.05$ ). The highest soluble solids contents were obtained for the samples concentrated by rotary evaporation. Samples concentrated using UF contained higher amount of total vitamin C while heat concentrated juice samples using a rotary evaporator retained the least amount of total vitamin C as expected. Apple juice concentrate contained the highest amount of total vitamin C regardless of concentration methods used. Each carrot juice concentrate contained the least amount of total vitamin C. In general, the characteristics of single juice concentrates was carried through to the blend juice concentrates.

## ACKNOWLEDGEMENTS

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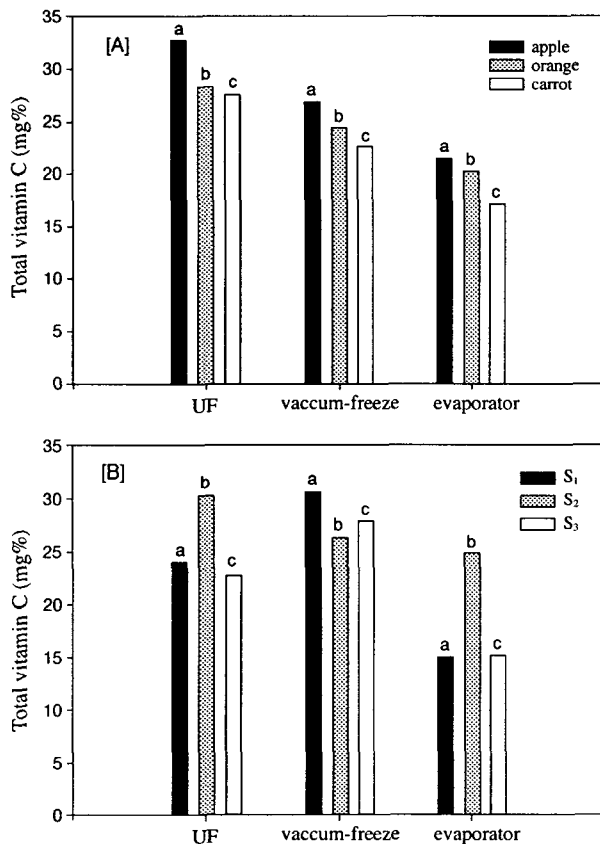


Fig. 3. Changes in total vitamin C contents as affected by concentration methods (A: single juice samples, B: blend juice samples). Means within a treatment with the same letter are not significantly different ( $p < 0.05$ ).

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