

Comparison of Nutritional Compositions and Antioxidant Activities of Building Blocks in Shinseoncho and Kale Green Vegetable Juices

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Abstract

Shinseoncho and kale were divided into stem [shinseoncho stems (SS) and kale stems (KS)] and leaf parts [shinseoncho leaves (SL) and kale leaves (KL)] and made into green vegetable juices for analyses of nutritional compositions and antioxidant activities. Higher values of total acidity were observed in SL (0.736%) and KL (0.841%) than in SS (0.417%) and KS (0.335%) ($p < 0.05$). Neutral sugar content showed higher values in SS (21.740 mg/mL) and SL (18.657 mg/mL) when compared with KS (1.497 mg/mL) and KL (1.452 mg/mL) ($p < 0.05$). Protein content showed the highest value in SL (7.610 mg/mL) ($p < 0.05$), while SS (0.403 mg/mL) and KS (0.403 mg/mL) showed similar lower values. Total polyphenol contents of SL (423.139 $\mu\text{g/mL}$) was significantly higher value ($p < 0.05$) than those of other samples, which occurred in the following order: SL > KL (218.494 $\mu\text{g/mL}$) > KS (107.269 $\mu\text{g/mL}$) > SS (75.894 $\mu\text{g/mL}$). KL exerted the highest DPPH radical scavenging activity (84.834%) ($p < 0.05$), which occurred in the following order: KL > SL (63.473%) > KS (52.894%) > SS (35.443%). ABTS radical scavenging activity showed that SL (66.088%) and KL (38.511%) had higher scavenging activities, whereas SS (7.695%) and KS (9.609%) demonstrated to be lower activities ($p < 0.05$). In general, leaf parts had much higher antioxidant activities as well as total polyphenol contents than those of the stem parts. In conclusion, shinseoncho and kale, particularly their leaf parts, offer antioxidant properties in green vegetable juices and the consumption of them may be beneficial as a nutrition source and in health protection.

Key words: green vegetable juice, shinseoncho, kale, nutritional composition, antioxidant activity

INTRODUCTION

The pathology of numerous chronic diseases, including cancer, heart disease, hypertension, involved oxidative damage to cellular components. Epidemiological studies show that many phytonutrients of fruits and vegetables may be beneficial to protecting the human body against damage by reactive oxygen and nitrogen species (1,2). Therefore, the intake of fruit and vegetable juices are recommended for a healthy diet and various health effects (3). Chronic diseases have reported related to lifestyle, which have increased recently. And these diseases are also closely related to the change of dietary habits; increase of animal protein and fat intakes and a decrease of the intake of dietary fibers. The research result in human nutrition and health has shown a deep relationship between diet and the increasing frequency of lifestyle diseases among the populations in industrialized countries (4). As a result, various original raw vegetable juices, as a functional food, have gained popularity to reduce the incidence of these diseases (5). Consumers are also becoming more conscious of the nutritional value and safety of their food ingredient for prevention of

chronic diseases. Preference for natural foods and food ingredients that are believed to be safer, healthier and less subject to hazards is increasing compared to their synthetic counterparts (6). Plants possess free sugars, organic acids, amino acids (free and in proteins), lipids and minerals which are natural components of many fruits and vegetables and they play an important role in maintaining fruit and vegetable quality and determining nutritive value in human diet (7). The determination of the nutritional composition of green vegetable juice including shinseoncho and kale has become an interest of ours due to its extensive consumption in Korea. However, most researchers have reported the nutritional composition values only on whole green vegetable juices without considering their building block (8-11). From this reason, the objective of present investigation was to examine the basic nutritional compositions and antioxidant activities of green vegetable juices including shinseoncho and kale, based on their building blocks. These results will be attributed to offer information of essential nutritional qualities and functionalities of the building blocks of fresh green vegetable juices.

MATERIALS AND METHODS

Preparation of green vegetable juice

Shinseoncho (*Angelica utilis makino*) and kale (*Brassica oleraceae* L. var. *acephala* DC.) were purchased from organic local market (Suwon, Korea) in July, 2012. The vegetables were washed twice with tap water, air dried for 3 hr at room temperature and then divided into stem [shinseoncho stems (SS) and kale stems (KS)] and leaf parts [shinseoncho leaves (SL) and kale leaves (KL)] by naked eye identification. The parts were ground with an electronic grinder (Hanil Electronics Corp., Wonju, Korea) after adding three times of distilled water based on the sample weight and then filtrated with four-fold guaze. The filtrated samples were centrifuged at 3,000 rpm for 10 min and used for nutritional composition and antioxidant activity analyses.

Nutritional composition analysis

The sample pH was measured with a pH meter. Total acidity, expressed as percent of citric acid, was determined by titrating with 0.01 N NaOH to pH 8.2. Neutral and acidic sugar contents were analyzed by phenol-sulfuric acid (12) and *m*-hydroxybiphenyl (13) methods, and then glucose and galacturonic acid were used as respective standard. Reducing sugar content was measured by the 3,5-dinitrosalicylic acid (DNS) method (14) using glucose as standard. Protein content was determined by Bradford's methods (15) using bovine serum albumin as standard.

Total polyphenol contents

The total polyphenol contents were determined using Folin-Ciocalteu method (16) with some modification. The total polyphenol concentration was calculated from a calibration curve using gallic acid as a standard. Briefly, 0.79 mL of distilled water, 0.01 mL of sample and 0.05 mL of Folin-Ciocalteu reagent were added to a 1.5-mL eppendorf tube and then mixed. After exactly 1 min, 0.15 mL of 20% sodium carbonate was added, and the mixture was then mixed. After incubation for 120 min at room temperature, the absorbance was then read at 750 nm.

DPPH radical scavenging activity

The DPPH radical scavenging activity was measured according to the method described by Cheung et al. (17), with some modifications. Briefly, 0.8 mL of 0.2 mM DPPH solution was mixed with 0.2 mL of sample. The mixture was then vigorously shaken and incubated under subdued light for 10 min. The absorbance was measured at 520 nm.

ABTS radical scavenging activity

The ABTS radical scavenging activity was measured according to the method described by Re et al. (18), with some modifications. The ABTS radical was generated by adding 7 mM ABTS to a 2.45 mM potassium persulfate solution and then allowing the mixture to stand overnight in the dark at room temperature. The ABTS radical solution was then diluted with distilled water to obtain an absorbance of 1.4~1.5 at 414 nm. Next, 1 mL diluted ABTS radical solution was added to 50 μ L sample. After incubation for 60 min at room temperature, the absorbance was measured at 414 nm.

Statistical analysis

All statistical analyses were conducted using the Statistical Package for Social Sciences, version 12.0 (SPSS Inc., Chicago, IL, USA). The differences among samples were evaluated statistically by one-way analysis of variance and Duncan's multiple tests. All data were evaluated at the 5% significance level using two-sided tests and are reported as the means \pm standard deviations of triplicate determinations.

RESULTS AND DISCUSSION

Nutritional composition analysis

The pH and total acidity of the samples are shown in Table 1. SS and SL showed higher pH value when compared with KS and KL. On the other hand, total acidity exhibited a higher value in SL (0.736%) and KL (0.841%) when compared with SS (0.417%) and KS (0.335%) ($p < 0.05$). This result showed that the leaf parts had much more organic acid content than the stem parts. As shown in Table 2, neutral sugar content showed higher value in SS (21.740 mg/mL) and SL (18.657 mg/mL) when compared with KS (1.497 mg/mL) and KL (1.452 mg/mL) ($p < 0.05$). Uronic acid sugar content was observed the highest value in SS (180.808 μ g/mL) ($p < 0.05$), which occurred in the following order: SS > SL (130.303 μ g/mL) > KS (108.989 μ g/mL) > KL (100.404 μ g/mL). Reducing sugar content showed higher values in SS (6.706 mg/mL) and SL (7.206 mg/mL) ($p < 0.05$) when com-

Table 1. pH and total acidity of building blocks in shinseoncho and kale green vegetable juices

Sample	pH	Total acidity (% citric acid)
Shinseoncho stems	6.093 \pm 0.005 ^{c1)}	0.417 \pm 0.009 ^b
Shinseoncho leaves	6.096 \pm 0.005 ^c	0.736 \pm 0.019 ^c
Kale stems	6.063 \pm 0.005 ^b	0.335 \pm 0.009 ^a
Kale leaves	6.050 \pm 0.000 ^a	0.841 \pm 0.032 ^d

¹⁾Significantly different at $p < 0.05$; different letters indicate significant differences among samples. Values are expressed as mean \pm standard deviation.

Table 2. Sugar components and protein content of building blocks in shinseoncho and kale green vegetable juices

Sample	Neutral sugar (mg/mL)	Uronic acid sugar ($\mu\text{g/mL}$)	Reducing sugar (mg/mL)	Protein content (mg/mL)
Shinseoncho stems	$21.740 \pm 1.282^{c1)}$	180.808 ± 23.144^b	6.706 ± 0.115^b	0.403 ± 0.018^a
Shinseoncho leaves	18.657 ± 0.535^b	130.303 ± 15.151^a	7.206 ± 0.305^c	7.610 ± 1.082^c
Kale stems	1.497 ± 0.136^a	108.989 ± 10.088^a	0.690 ± 0.032^a	0.403 ± 0.052^a
Kale leaves	1.452 ± 0.341^a	100.404 ± 12.152^a	0.840 ± 0.000^a	1.867 ± 0.388^b

¹⁾Significantly different at $p < 0.05$; different letters indicate significant differences among samples. Values are expressed as mean \pm standard deviation.

pared with KS (0.690 mg/mL) and KL (0.840 mg/mL). In general, shinseoncho green vegetable juice showed higher sugar content than kale green vegetable juice regardless of their building blocks. Protein content showed the highest value in SL (7.610 mg/mL) ($p < 0.05$) and SS (0.403 mg/mL) and KS (0.403 mg/mL) showed the similar lower values. The protein content of SL was observed at about 19 times higher than those of SS and KS. When comparing the building blocks, the leaf parts showed much higher protein values than those of the stem parts. However, KL (1.867 mg/mL) was observed at a relatively lower value when compared with SL. Total analyses of nutritional compositions, neutral and reducing sugars and protein contents, demonstrated that shinseoncho juice has a greater nutritional value in all aspects than kale juice.

Total polyphenol contents

At present, an important area of food research is the development of physiological functional foods. Phenolic compounds constitute a large group of secondary metabolites widely distributed in the plant kingdom and have received enormous interest from researchers and food manufacturers within the past ten years. More than 8,000 polyphenols have been identified, and evidence for a role in the prevention of degenerative diseases, including cancer and cardiovascular diseases, is emerging (19). Major mechanisms for the antioxidant effect of phenolics in functional foods include free radical scavenging and metal chelation activities. Reactive oxygen species (ROS), such as the superoxide radical (O_2^-), hydrogen peroxide (H_2O_2), hypochlorous acid (HOCl) and the hydroxyl radical ($\text{HO}\cdot$) have been recognized to play a determining role in the pathogenesis of several human diseases (20,21). Total polyphenols are commonly quantified using the Folin-Ciocalteu method (22). The present study determined the antioxidant capacities of SS, SL, KS, and KL, and the total polyphenol content may contribute to the antioxidant activities of the building blocks within the green vegetable juices. Total polyphenol contents of the green vegetable juices were evaluated using the Folin-Ciocalteu method in this study (Fig. 1). The total polyphenol contents of SL (423.139 $\mu\text{g/mL}$) were

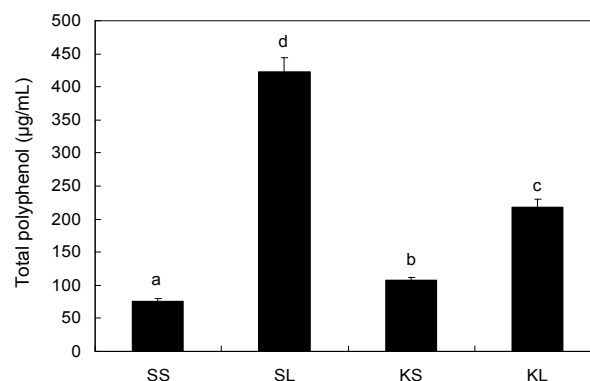


Fig. 1. Total polyphenol contents of building blocks in shinseoncho and kale green vegetable juices. SS: shinseoncho stems, SL: shinseoncho leaves, KS: kale stems, KL: kale leaves. Different letters indicate significant differences at $p < 0.05$ among samples. Bars are mean \pm standard deviation.

significantly higher value ($p < 0.05$) than other samples, which occurred in the following order: SL > KL (218.494 $\mu\text{g/mL}$) > KS (107.269 $\mu\text{g/mL}$) > SS (75.894 $\mu\text{g/mL}$). These results showed that the leaf parts offered greater total polyphenol contents when compared with the stem parts.

DPPH and ABTS radical scavenging activities

The interest of finding natural antioxidants has considerably increased since research has shown the impact these compounds have on the management of a variety of clinical conditions and maintenance of health. Vegetable juices are a good source of many biologically active antioxidant compounds (23). Recent studies have begun to demonstrate that a number of vegetable juices display high total antioxidant capacities when quantified using biochemical assays (24). Such assays rely on either single electron transfer (SET) or hydrogen atom transfer (HAT) reaction kinetics and comparisons are made between similar types of assays (25). SET assays such as DPPH radical and ABTS radical scavenging activities are simple, cost effective, easily interpreted and display either reduction capacity or direct free radical inhibition. This present study was employed SET assay which could be analyzed by common spectrophotometric procedures for determining the antioxidant capacities of components, which were quantified in terms of percentage inhibition of a pre-formed free radical by antioxidants in

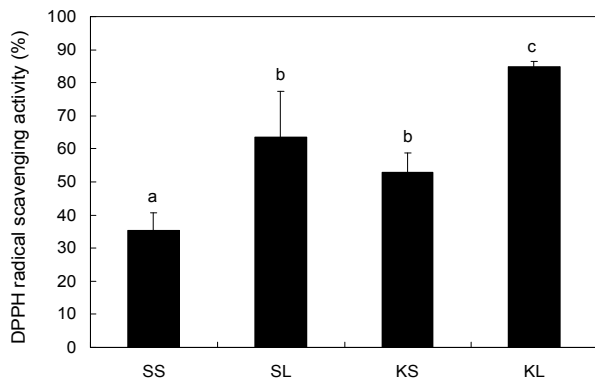


Fig. 2. DPPH radical scavenging activities of building blocks in shinseoncho and kale green vegetable juices. SS: shinseoncho stems, SL: shinseoncho leaves, KS: kale stems, KL: kale leaves. Different letters indicate significant differences at $p < 0.05$ among samples. Bars are mean \pm standard deviation.

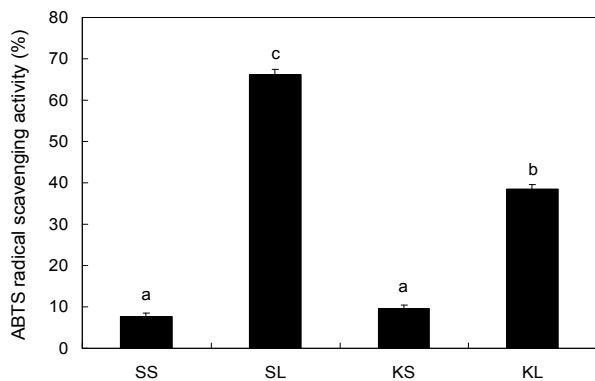


Fig. 3. ABTS radical scavenging activities of building blocks in shinseoncho and kale green vegetable juices. SS: shinseoncho stems, SL: shinseoncho leaves, KS: kale stems, KL: kale leaves. Different letters indicate significant differences at $p < 0.05$ among samples. Bars are mean \pm standard deviation.

each sample. The results are shown in Fig. 2 and 3, respectively. Among samples, KL exerted the highest DPPH radical scavenging activity (84.834%) ($p < 0.05$), which occurred in the following order: $KL > SL (63.473\%) > KS (52.894\%) > SS (35.443\%)$. Namely, DPPH radical scavenging activities of the leaf parts were observed at higher values compared to the stem parts. The results of the ABTS radical scavenging activity showed that SL (66.088%) and KL (38.511%) were observed at relatively higher activities, whereas SS (7.695%) and KS (9.609%) resulted in lower values ($p < 0.05$). These results showed that the leaf part had better DPPH and ABTS radical scavenging activities than those of the stem parts.

Ayaz et al. (10) have reported that citric and malic acids are two major organic acids detected in kale leaves. Total acidity, expressed as a citric acid, was higher in SL and KL parts than those of SS and KS in this study (Table 1), concluding that the leaf parts had more organ-

ic acid content than the stem parts. Citric acid has been beneficial in reducing hydrogen peroxide (H_2O_2) formation, which is not very reactive, but it can sometimes be toxic within cells because it may give rise to hydroxyl radical in the cell (1). Thus, removal of H_2O_2 is very important for antioxidant defense in cell or food systems.

Phenolic compounds, which are present in high quantities in human foods and beverages derived from plant and fruits, are potent blocking agents of *N*-nitrosamine compound formation (26). Vegetables are rich in bioactive compounds, including tocopherols, ascorbic acid, carotenoids, glucosinolates and polyphenols (27), and are found to have positive effects on human health when consumed regularly (28). Scavenging of H_2O_2 by kale and shinseoncho may be attributed to their phenolics, which could donate electrons to H_2O_2 (29). Lee et al. (30) have also reported that kale juice showed a strong antimutagenic activity against aflatoxin B_1 . Phytophenolics play a crucial role in health promotion and disease prevention by mechanisms related to cell differentiation, deactivation of pro-carcinogens, maintenance of DNA repair, inhibition of *N*-nitrosamine formation and changes of estrogen metabolism (31). Phenolic compounds such as phenolic acids, flavonoids, stilbenes, tannins and lignans can scavenge free radicals and quench ROS and therefore provide effective means for preventing and treating free radical-mediated diseases (32). Our results indicated that SL had higher total polyphenol contents (Fig. 1) and showed predominant DPPH and ABTS radical scavenging activities (Fig. 2 and 3). However, although KL showed relatively lower total polyphenol contents when compared with SL it was observed higher DPPH radical scavenging activity. Concurrently, KL had a lower ABTS radical scavenging activity than those of SL. Obviously, leaf parts had much higher total polyphenol contents as well as DPPH and ABTS radical scavenging activities than those of stem parts ($p < 0.05$). Epidemiological evidence suggests that diet and nutrition may have a significant effect in the prevention of serious diseases and potentially, a very significant effect on broad range of public health (33).

Overall, the results showed that shinseoncho green vegetable juice has a greater nutritional value than kale green vegetable juice in all aspects, particularly in the neutral sugar, reducing sugar and protein contents. When considering the building blocks, neutral sugar and uronic acid contents demonstrated the highest values in the SS part, whereas SL part showed the highest value of reducing sugar and protein contents than any other building blocks. The SL part had higher amount of total polyphenol content when compared with SS, KS, and KL

parts, which generally exerted good antioxidant activities against DPPH and ABTS radicals.

In conclusion, fresh shinseoncho and kale green vegetable juices are high in antioxidant properties and may beneficially enhance the body's antioxidant protection system against oxidative damage. The results from this study suggest that the consumption of SL part could be useful as a nutrition source as well as maintaining and promoting health.

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