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Comparative evaluation of physicochemical properties and antioxidant activity of fresh vegetable juices extracted using low-speed masticating household juicer

가정용 저속 착즙기를 이용해 제조한 채소 주스의 이화학적 성질과 항산화 활성 비교 평가

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Abstract

한국을 포함한 대부분의 국가들에서는 채소 섭취량이 권장량 이하인 것으로 보고되고 있다. 이를 증가시키기 위한 다양한 노력이 진행됨에 따라 100% 착즙 주스에 대한 관심이 증가하고 있으며, 국내외에서는 가정용 저속 착즙기 시장이 성장하고 있는 추세이나 착즙 주스의 항산화능을 비교 분석한 연구는 매우 부족한 실정이다. 따라서, 본 연구에서는 가정용 저속 착즙기로 제조한 당근, 양배추, 브로콜리, 케일 착즙 주스의 이화학적 특성을 비롯하여 폴리페놀, 플라보노이드, 항산화 효소 활성을 비교 분석하였다. 또한, 열처리 조건에 따른 착즙 주스의 항산화 효소 활성을 비교 평가하였다. 실험 결과, 브로콜리 주스의 총 폴리페놀이 가장 높게 나타났으며, 케일, 양배추, 당근 주스 순으로 나타났다. 총 플라보노이드의 경우 당근주스가 가장 함량이 높았고 브로콜리, 케일, 양배추 주스 순으로 나타났다. 또한, 네 종류의 착즙 주스에서 측정한 2,2-diphenyl-1-picrylhydrazyl 라디칼 소거능 결과는 양배추 주스가 가장 높았으며, 브로콜리, 케일, 당근 주스 순으로 나타났다. 항산화 효소인 catalase 활성은 케일과 브로콜리 주스가 당근 및 양배추 주스에 비해 유의적으로 높게 나타났다. 양배추와 브로콜리 착즙 주스를 60°C에서 5분 및 10분, 80°C에서 3분 열처리한 결과, 열처리 온도와 시간이 증가함에 따라 catalase 활성이 유의미하게 감소하는 것을 확인하였으며 열처리에 따른 catalase 감소폭은 브로콜리 주스가 더욱 크게 나타났다. 본 연구를 통해 다소비 채소에 대한 착즙 주스의 항산화능을 종합적으로 평가하였으며, 추가 분석을 통해 착즙 주스의 영양학적 성분을 구축하는 것이 필요할 것으로 사료된다.

주제어: 채소, 항산화, 폴리페놀, 플라보노이드, 카탈라아제

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Ⅰ. Introduction

Healthy eating patterns are defined as a diet consisting of vegetables, fruit, fish, whole grains, and low-fat dairy products (Jayedi et al., 2020). Based on a meta-analysis, a healthy dietary pattern is negatively correlated with the risk of type 2 diabetes, cardiovascular disease (CVD), and premature death (Jayedi et al., 2020). A higher risk of all-cause death is also linked to poor food quality, related to an unhealthy diet [hazard ratio (HR), 1.22; 95% confidence interval (CI), 1.06-1.40] (Lim et al., 2018). The Food and Agriculture Organization (Rome, Italy) and World Health Organization (Geneva, Switzerland) recommend consuming vegetables at least three times a day, amounting to approximately 240 g (Kalmpourtzidou et al., 2020; World Health Organization, 2003). However, a study analyzed 162 countries to assess vegetable intake and revealed that the average consumption was 186 g/day, indicating that 88% of the countries surveyed consumed less than the recommended amount of vegetables (Kalmpourtzidou et al., 2020). The Korean Nutrition Society (Seoul, Korea) also recommends that adults consume a minimum of eight servings of vegetables per day, which is approximately 560 g (Hwang et al., 2022). However, based on the Korea National Health and Nutrition Examination Survey report, the daily total vegetable intake of Koreans increased slightly from 279.4 g in 1998 to 285.6 g in 2016-2017, indicating no significant increase in vegetable consumption among Koreans over the past 20 years (Kim et al., 2021). Additionally, vegetable intake among adolescents and adults in South Korea has shown a decreasing trend over the past 20 years in Korea (Kim et al., 2021).

A United Kingdom cohort study, which was a 12-year follow-up study of participants without pre-existing CVD, found that the intake of raw vegetables was associated with a reduced risk of CVD incidence (HR, 0.89; 95% CI, 0.83-0.95) and mortality (HR, 0.85; 95% CI, 0.74-0.97) (Feng et al., 2022). A prospective cohort study (Miller et al., 2017) conducted across 18 countries with 135,335 participants with a 7.4-year follow-up on vegetable intake, CVD events, and mortality also revealed that the high level of consumption of raw vegetables significantly reduced CVD mortality (HR, 0.69; 95% CI, 0.55-0.85). The consumption of cooked vegetables interestingly did not show a significant correlation with reduced risk for these outcomes (Feng et al., 2022; Miller et al., 2017). Therefore, although adequate vegetable intake is recommended to prevent chronic diseases and reduce related mortality, actual consumption still falls short of the recommended levels (Kalmpourtzidou et al., 2020; Kim et al., 2021).

A previous study (Shenoy et al., 2010) reported that vegetable juice supplementation increases dietary vegetable intake. As the demand for convenient and easy consumption of vegetables and fruits has increased, the global juice market has grown rapidly, with a steady annual growth rate of 4% (Priyadarshini & Priyadarshini, 2018). In particular, a growing trend is customer demand for 100% natural juices (Priyadarshini & Priyadarshini, 2018). Aiso et al.(2014) report that providing fresh juice to healthy participants for 4 weeks resulted in a significant reduction in total cholesterol and low-density lipoprotein cholesterol, compared to the commercial juice group. Choi et al.(2014) compared the chemical composition of juices, based on different juicing methods and the nutritional components of commercial juices. Low-speed juicers exhibit superior juice extraction efficiency, digestive enzyme activity, and antioxidant activity, compared to high-speed juicers and blender methods (Choi et al., 2014).

Therefore, the consumption of fresh juice is expected to provide more health benefits, in addition to increasing the total vegetable intake. Studies analyzing freshly squeezed juices from commonly consumed vegetables remain limited. Research is lacking on the biochemical properties and antioxidant content of freshly squeezed vegetable juice. Furthermore, studies investigating the changes in physicochemical properties and antioxidant enzyme activity associated with the cooking methods commonly used for cabbage and broccoli consumption, such as boiling or steaming, are limited. Therefore, in this study, we selected four vegetables commonly used in households and compared their physicochemical properties and antioxidant effects by using a low-speed masticating (LSM) juicer. Additionally, we compared the antioxidant enzyme activities of cabbage and broccoli, which are commonly consumed as blanched foods, under different heat-treatment conditions.

Ⅱ. Methods

1. Preparation of the samples

Carrot, cabbage, kale, and broccoli were purchased from a market in Gimhae, South Korea in February 2023. All materials were thoroughly washed with tap water and cut into small pieces. Juices were prepared using an LSM juicer (H420; Hurom Co., Ltd., Gimhae, Korea), based on the manufacturer's instructions. The extraction yields of the carrot, cabbage, kale, and broccoli juices were 53.4%, 56.7%, 54.0%, and 34.4% respectively. The fresh juices underwent heat treatment using a water bath set at the temperatures of 60°C for 5 minutes and 10 minutes, and 80°C for 3 minutes. Fresh and heat-treated juices were centrifuged at 3,000 × g for 15 minutes at 4°C (Eppendorf Centrifuge 5415R; Eppendorf, Hamburg, Germany). The resulting supernatant was used for catalase activity analysis. The juices were mixed with methanol at a 1:4 (v/v) ratio and incubated at room temperature for 1 hour. All incubated samples were subsequently centrifuged at 3,000 × g at 4°C for 10 minutes to obtain the supernatant, which was used for the analysis of total polyphenol and flavonoid levels and 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical-scavenging activity. All samples were immediately stored at －70°C until further analysis (SW-UF-120 freezer; Samwon Freezing Engineering Co., Busan, Korea).

2. Determination of total soluble solids and color

The total soluble solids in the fresh juices were measured immediately after extraction by using a refractometer (Pal-1; Atago, Tokyo, Japan). The color of fresh juices was measured, using a colorimeter (CR200; Minolta, Osaka, Japan). The L, a, and b values of the standard plate were 96.75, a = -0.19, b and 20.

3. Total polyphenol analysis

The polyphenol was measured using the method described by Singleton et al.(1999). In brief, 200 µL of 50% Folin-Ciocalteu's phenol reagent was added to 400 µL of the supernatant. After 3 minutes, 400 µL of 2% sodium carbonate (Na_2CO_3) was added into the mixtures and incubated at roomtemperature for 1 hour. Absorbance was measured at 750 nm using a spectrophotometer (SpectraMax M2; MolecularDevices, SanJose, CA, USA). The polyphenol was measured using tannic acid as the reference standard, and the results were expressed as mg of tannic acid equivalents (TAE) per 1 mL of juice.

4. Total flavonoid analysis

The flavonoid content was analyzed using the method developed by Moreno et al.(2000): 30µL of 5% sodium nitrite ($NaNO_2$) solution was mixed with 400 µL of the supernatant. After 5 minutes of incubation, 300 µL of 1% aluminumchloride ($AlCl_3$) solution was added, and the mixture was allowed to stand for 6 minutes. Two hundred microliters of 1 M sodiumhydroxide (NaOH) solution was then added, and the final volume of the mixture was brought to 1mL with distilled water. The absorbance was measured at 510 nm using a spectrophotometer. The flavonoid was measured using quercetin as the reference standard. The results were reported as mg of quercetin equivalents (QE) per 1 mL of juice.

5. DPPH radical-scavenging activity

Methanol-extracted samples were used to determine the DPPH radical-scavenging activity. The DPPH radical-scavenging activity was measured using the method developed by Blois et al (Blois et al., 1958): 0.8 mL of

0.1mM DPPH solution in 80% ethanol was added to an aliquot (0.2 mL) of each sample, followed by incubation in the dark for 10 min at room temperature. The decrease in absorbance (Abs) owing to the proton-donating activity of the antioxidants was measured at 517 nm. DPPH radical-scavenging activity was calculated by using the following formula: [1 - ((Abs of sample - Abs of control)/Abs of control)] ×100.

6. Analysis of catalase activity

Catalase activity was measured, based on the method described by Abei (Abei, 1974): 100 µL of the supernatant was added to the 2.9 mL of the 30mM hydrogen peroxide (H_2O_2) solution. The change in absorbance was measured at 240nm for 3 minutes to determine catalase activity. As a control, instead of the substrate H_2O_2 solution, 2.9 mL of 50 mM phosphate buffer (pH7.0) was added, and the change in absorbance was measured under the same conditions. Enzyme activity was defined as the amount of enzyme that decomposes 1µ mole of substrate per minute, expressed as 1 unit.

7. Statistical analyses

All experiments were conducted in triplicate and expressed as the mean ± the standard deviation. One-way analysis of variance was used to evaluate the statistical significance of differences among groups, followed by Tukey's test. The results were deemed statistically significant at a significance level of $p < 0.05$ (SPSS ver. 27; IBM Corp., Armonk, NY, USA).

Ⅲ. Results

1. Physicochemical analysis of the fresh juices

The color and Brix values of the extracted juices are summarized in Table 1. The L value, representing brightness, followed the order of cabbage, carrot, broccoli, and kale juice, whereas the a and b values, indicating redness and yellowness, respectively, were significantly higher in carrot juice ($p < 0.05$). Among the four types of vegetable juices, carrot juice exhibited the highest Brix value, whereas broccoli juice had the lowest Brix value ($p < 0.05$).

2. Total polyphenol and flavonoid analysis findings of the fresh juices

The total polyphenol and flavonoid contents of the carrot, cabbage, kale, and broccoli juices are presented in Table 2. The polyphenol content of broccoli juice was

〈Table 1〉 Physicochemical evaluation of the fresh juices

		Carrot	Cabbage	Kale	Broccoli
Hunter's value	L	33.58 ± 0.04^{c}	36.33 ± 0.09^{d}	27.89 ± 0.01^{a}	32.81 ± 0.03^{b}
	a	6.89 ± 0.01^{d}	-1.14 ± 0.01^{b}	-0.96 ± 0.00^{c}	-4.31 ± 0.01^{a}
	b	6.06 ± 0.06^{d}	5.35 ± 0.05^{c}	0.44 ± 0.00^{a}	4.79 ± 0.01^{b}
°Brix		9.25 ± 0.07^{d}	8.75 ± 0.07^{c}	8.15 ± 0.07^{b}	7.65 ± 0.07^{a}

$^{a\text{-}d}$Values within a row that do not share a common letter are significantly different at $p < 0.05$.
The L value represents brightness and the a and b values indicates redness and yellowness, respectively.

〈Table 2〉 Total polyphenol and flavonoid content of the fresh juices

	Carrot	Cabbage	Kale	Broccoli
Polyphenol (TAE mg/mL)	0.13 ± 0.01^{a}	0.30 ± 0.02^{b}	0.34 ± 0.01^{bc}	0.38 ± 0.01^{c}
Flavonoid(QE mg/mL)	0.78 ± 0.11^{d}	0.25 ± 0.02^{a}	0.41 ± 0.02^{ab}	0.61 ± 0.11^{cd}

$^{a\text{-}d}$ Values within a row that do not share a common letter are significantly different at $p < 0.05$.

the highest, followed by kale, cabbage, and carrot juices in decreasing order ($p < 0.05$). The flavonoid content of carrot juice was significantly higher than that of the other juices, followed by broccoli and kale juices ($p < 0.05$). Among the four juices tested, cabbage juice had the lowest flavonoid content ($p < 0.05$).

3. Analysis of DPPH radical-scavenging and catalase activities in the fresh juices

The results of the DPPH radical-scavenging and catalase activities for the four types of juices are shown in Table 3. The DPPH radical-scavenging ability of cabbage juice was the highest at 92.36%. Broccoli juice had the second-highest DPPH radical-scavenging activity, followed by kale and carrot juices in decreasing order ($p < 0.05$). The measurement of catalase activity in the four juices revealed that kale and broccoli juices had higher catalase activities compared to carrot and cabage juices ($p < 0.05$).

4. Catalase activity changes after heat treatment of the juices

A comparison of the activity of catalase, an antioxidant enzyme, in cabbage and broccoli juices after heat treatment is presented in Fig. 1. The catalase activity of the cabbage and broccoli juices before heat treatment was 19.15 ± 0.92 and 26.80 ± 0.87 U/mL, respectively. After heat treatments at 60°C for 5 minutes and 10 minutes, and 80°C for 3 minutes, both juices had a significant decrease in catalase activity ($p < 0.05$).

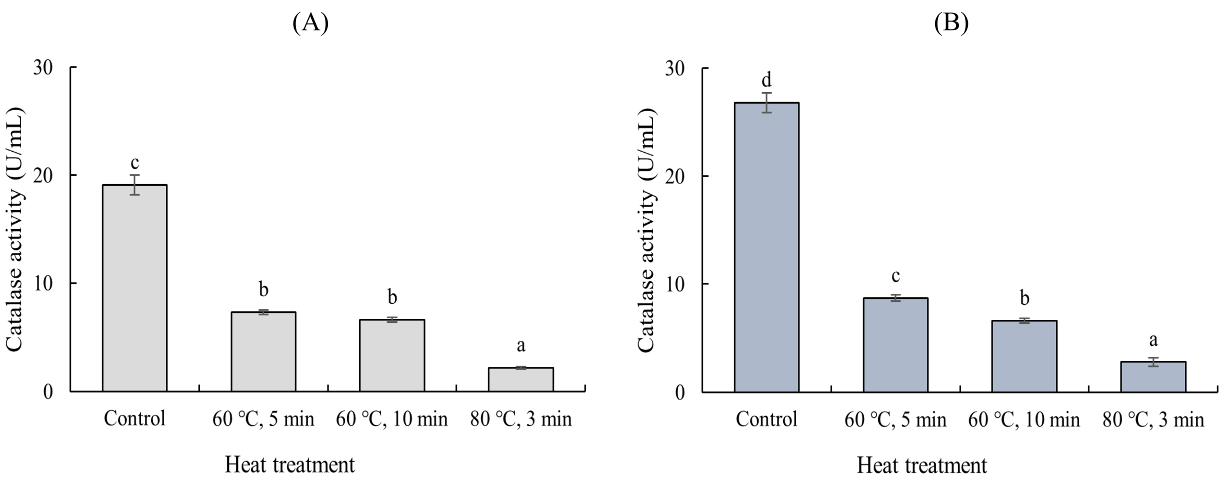
5. Physicochemical changes in the juices under heat treatment

Color and Brix changes in cabbage and broccoli juices were observed after heat treatment in Table 4. The results were that, for both juices, the L and b values increased significantly with heat treatment, whereas the a value decreased significantly. The Brix value of

〈Table 3〉 DPPH radical scavenging and catalase activities of the fresh juices

	Carrot	Cabbage	Kale	Broccoli
DPPH radical scavenging activity (%)	62.90 ± 0.10^{a}	92.36 ± 0.06^{d}	71.19 ± 0.45^{b}	89.19 ± 0.38^{c}
Catalase activity (U/mL)	19.15 ± 0.92^{a}	17.96 ± 0.46^{a}	28.12 ± 1.42^{b}	26.80 ± 0.87^{b}

$^{a-d}$ Values within a row that do not share a common letter are significantly different at $p < 0.05$.



[Figure 1] Catalase activities of the (A) cabbage juice and (B) broccoli juice

$^{a-d}$Bars that do not share a common letter are significantly different at $p < 0.05$.

broccoli juice significantly increased with heat treatment, whereas no significant difference existed in the Brix value of cabbage juice before and after heat treatment.

Ⅳ. Discussion

In this study, we utilized a household juicer to extract juices from broccoli, kale, cabbage, and carrots and measured the total polyphenol and flavonoid contents, as well as the antioxidant enzyme activity of the freshly extracted juices. The results indicated that, among the four vegetable juices, broccoli juice had the highest total polyphenol content, whereas carrot juice had the highest total flavonoid content. Polyphenols are chemical compounds primarily found in plants that exist as structures containing one or more phenolic rings (Vidal-Casanella et al., 2022). Hundreds of polyphenols can be found in plants, and they can be classified, based on their structures, into categories such as phenolic acids, flavonoids, and tannins (Del Bo’ et al., 2019).

Total polyphenols possess excellent antioxidant capabilities, making them effective in reducing oxidative stress and preventing CVD (Arts & Hollman, 2005). Some cohort studies have reported a relationship between the intake of polyphenols and flavonoids from everyday meals and risk reduction of diabetes and CVD (Miranda et al., 2016; Goetz et al., 2016). Goetz et al.(2016) found that a higher total polyphenol intake is associated with a 46% reduction in the risk of CVD events. Additionally, a higher total flavonoid intake has been linked to a 10% reduction in the risk of diabetes (Miranda et al., 2016). Furthermore, reports indicate that a daily intake of > 900 mg of total polyphenols and over 500 mg of total flavonoids is effective in preventing the occurrence of CVD and reducing the risk of mortality (Del Bo’ et al., 2019). An investigation of daily flavonoid intake among Korean adults revealed an average intake of approximately 96.6 mg/day, with kimchi identified as the primary dietary source (Kim et al., 2015). This intake level was reported to be lower than that in Western countries, which ranged from 176.8 to 182.2 mg/day (Beking & Vieira, 2011; Kim et al., 2015). Therefore, efforts are needed to increase the consumption of polyphenol-rich vegetable juices, which are beneficial for meeting daily vegetable intake requirements and for increasing the overall polyphenol consumption.

In this study, the measurement of the DPPH radical-scavenging activity revealed that cabbage had the highest activity, followed by, in descending order, broccoli, kale, and carrot. Choi et al.(2014) measured the DPPH radical-scavenging activity of 12 different vegetable and fruit juices and found that juices with darker colors such as kiwi and grapes exhibited superior DPPH radical-scavenging activity. By contrast, juices with lighter colors such as carrot and papaya have lower DPPH radical-scavenging activity (Choi et al., 2014). This finding is consistent with the results of our study, in which darker-colored juices had superior DPPH radical-scavenging activity compared to lighter-colored carrot juice. In a previous study (Ferreira et al., 2015), the DPPH radical-scavenging activities of broccoli, cabbage, kale, and carrot extracts were measured, and the results showed that the order of effectiveness was broccoli > kale >

〈Table 4〉 Changes in color parameters and °Brix after heat treatment in the cabbage juice and broccoli juice

	Cabbage				Broccoli			
	L	a	b	°Brix	L	a	b	°Brix
Control	36.3 ± 0.1^{a}	-1.1 ± 0.0^{c}	5.3 ± 0.0^{a}	8.8 ± 0.1^{b}	32.8 ± 0.0^{c}	-4.3 ± 0.0^{bc}	4.8 ± 0.0^{c}	7.7 ± 0.1^{a}
60 ℃, 5 min	37.2 ± 0.0^{b}	-3.1 ± 0.1^{b}	5.8 ± 0.0^{c}	8.6 ± 0.1^{b}	32.2 ± 0.0^{a}	-4.3 ± 0.0^{a}	4.5 ± 0.0^{a}	8.1 ± 0.1^{b}
60 ℃, 10 min	37.1 ± 0.1^{b}	-3.1 ± 0.1^{b}	5.8 ± 0.0^{c}	8.4 ± 0.1^{a}	32.3 ± 0.0^{b}	-4.4 ± 0.0^{b}	4.7 ± 0.0^{b}	8.3 ± 0.1^{c}
80 ℃, 3 min	37.7 ± 0.1^{c}	-3.4 ± 0.1^{a}	5.6 ± 0.1^{b}	8.7 ± 0.1^{b}	33.7 ± 0.0^{d}	-5.6 ± 0.0^{a}	5.5 ± 0.0^{d}	8.4 ± 0.1^{c}

[a-d]Values within a column that do not share a common letter are significantly different at $p < 0.05$.
The L value represents brightness and the a and b values indicates redness and yellowness, respectively.

cabbage > carrot. The DPPH radical-scavenging activity was positively correlated with the total polyphenol compounds (r = 0.918) (Ferreira et al., 2015).

In another study (Tekle et al., 2015), *Moringa oleifera* extracts were prepared using different solvents, and the total polyphenol content and DPPH radical-scavenging activity were measured. The results indicated that a higher total polyphenol content corresponded with superior DPPH radical-scavenging activity (r = 0.760). We also analyzed the relationship between total polyphenol content and DPPH radical-scavenging activity, which yielded a high correlation coefficient of 0.696, although we observed no significant correlation (data not shown). We speculate that with further analyses of a larger number of juice samples, significant results similar to those of previous studies will be obtained.

Plants have abundant antioxidant enzyme activity, including catalase, which serves as a defense mechanism against reactive oxygen species (ROS) such as superoxide anion radicals ($O2\cdot$), H_2O_2, hydroxyl free radicals ($\cdot OH$), and other ROS (Del Rio et al., 1998; Desikan et al., 1996). This activity is linked to processes such as photorespiration and reactions involving membrane-bound oxidases in plant cells (Del Rio et al., 1998). Consequently, consuming vegetables rich in antioxidant enzymes is considered advantageous for mitigating oxidative stress in the body. However, the enzymatic activity of these vegetables can vary depending on the cooking methods employed (Anderson, 2002; Erguder et al., 2007).

A study (Erguder et al., 2007) comparing the antioxidant enzyme activity of vegetables and fruits, based on different cooking methods, demonstrated that the antioxidant enzyme activity, except for that of tomatoes, was significantly higher in the raw state than after boiling, microwaving, and baking. Other research also showed that as the temperature increased, the catalase activity decreased when pepper leaves were treated at 24°C, 48°C, and 54°C for 15 minutes (Anderson, 2002). In particular, when treated at temperatures above 50°C, the catalase activity decreased by approximately 90%, compared to the activity at 24°C (Anderson, 2002). These findings are consistent with the results of our study, indicating a decrease in catalase activity due to heat treatment.

A previous study reported a significant increase in serum antioxidant enzyme activity and a significant decrease in lipid peroxidation levels after 3 months of administering polyphenol-rich chokeberry juice to healthy participants (Kardum et al., 2014). Phenolic compounds directly respond to oxidative stress by scavenging electrons from free radicals, thereby generating stable phenoxyl radical (Scalbert et al., 2005). Additionally, by forming complexes with iron and copper, polyphenols inhibit free radical catalytic reactions and enhance the activity of antioxidant enzymes, thereby exhibiting antioxidant effects (Mitjavila & Moreno, 2012). Therefore, consuming fresh vegetable juices (100-300 mL/day) rich in polyphenols and catalase enzymes may help increase oxidative stress defense.

The heat treatment of cabbage and broccoli juices resulted in a significant increase in the brightness of the juices, accompanied by a significant decrease in yellowness. This outcome aligns with previous research findings, in which apple juice treated with high-temperature sterilization exhibited increased brightness and decreased yellowness, compared with apple juice treated with low-temperature sterilization (Lee et al., 2012).

In this study, we measured the antioxidant components and enzyme activities of fresh vegetable juices extracted using a household juicer. In particular, we examined the changes in antioxidant enzyme activity due to the heat treatment of extracted fresh vegetable juices. The demand for convenient ways to consume fruits and vegetables has been steadily increasing, and a growing proportion of individuals are opting for squeezed juices (Priyadarshini & Priyadarshini, 2018). However, research on the nutritional analysis of these freshly squeezed juices remains limited. Therefore, this study holds significant value as it provides a detailed analysis of the physiological activity of vegetable juices produced using a household juicer. Nevertheless, the study has limitations: it did not conduct comparisons, based on the juicing method, and it did not analyze differences, compared with raw materials and commercially available juices. Finally, we did not include a comparative analysis of enzyme activity changes under heat treatment for all the squeezed juices utilized in the experiments. Although these studies are limited in scope, our results provide fundamental data for future research aimed at elucidating the physiological activities of juiced vegetables.

Abstract

Vegetable intake in Korea and other countries has been reported to be less than recommended levels. Consequently, various efforts are being made to increase vegetable consumption, and One notable change is a rapid growth of the home juicer market. In this study, we aimed to compare antioxidant and enzyme activities of vegetable juices made using a home juicer. In this study, carrots, cabbage, broccoli, and kale were extracted using a low-speed masticating juicer to measure physicochemical properties, polyphenols, flavonoids, and catalase activity. We also compared chemical properties of fresh juices and catalase enzyme activities under different heat treatment conditions. Results: The Total polyphenol content was significantly higher in broccoli juices, Total flavonoid content was also significantly higher in carrot juice than in other juices. The order of DPPH radical scavenging activity was as follows: cabbage juice > broccoli juice > kale juice > carrot juice. Additionally, catalase activity was significantly higher in kale and broccoli juices than in carrot and cabbage juices. Furthermore, it was established that heating fresh juices deactivated the catalase activity in cabbage and broccoli juices. Broccoli juice exhibited the highest levels of polyphenols and antioxidant properties among the four juices. The intake of vegetable juices rich in polyphenols and flavonoids might serve as a valuable source of antioxidant nutrients, particularly beneficial for Koreans with inadequate vegetable consumption.

Keywords: Vegetable, Antioxidant, Polyphenol, Flavonoid, Catalase

REFERENCES

Aebi, H. (1974). *Catalase. In Methods of Enzymatic Analysis* (pp. 673-684). Academic press.

Aiso, I., Inoue, H., Seiyama, Y., & Kuwano, T. (2014). Compared with the intake of commercial vegetable juice, the intake of fresh fruit and komatsuna (Brassica rapa L. var. perviridis) juice mixture reduces serum cholesterol in middle-aged men: a randomized controlled pilot study. *Lipids in Health and Disease*, *13*, 1-8.

Anderson, J. A. (2002). Catalase activity, hydrogen peroxide content and thermotolerance of pepper leaves. *Scientia Horticulturae*, *95(4)*, 277-284.

Arts, I. C., & Hollman, P. C. (2005). Polyphenols and disease risk in epidemiologic studies. *The American Journal of Clinical Nutrition*, *81(1)*, 317S-325S.

Beking, K., & Vieira, A. (2011). An assessment of dietary flavonoid intake in the UK and Ireland. *International Journal of Food Sciences and Nutrition*, *62(1)*, 17-19.

Blois, M. S. (1958). Antioxidant determinations by the use of a stable free radical. *Nature*, *181(4617)*, 1199-1200.

Choi, M. H., Kim, M. J., Jeon, Y. J., & Shin, H. J. (2014). Quality changes of fresh vegetable and fruit juice by various juicers. *KSBB Journal*, *29(3)*, 145-154.

Del Bo', C., Bernardi, S., Marino, M., Porrini, M., ... & Riso, P. (2019). Systematic review on polyphenol intake and health outcomes: is there sufficient evidence to define a health-promoting polyphenol-rich dietary pattern?. *Nutrients*, *11(6)*, 1355.

Del Rio, L. A., Pastori, G. M., Palma, J. M., Sandalio, L. M., ... & Hernández, J. A. (1998). The activated oxygen role of peroxisomes in senescence. *Plant Physiology*, *116(4)*, 1195-1200.

Desikan, R., Hancock, J. T., Coffey, M. J., & Neill, S. J. (1996). Generation of active oxygen in elicited cells of Arabidopsis thaliana is mediated by a NADPH oxidase like enzyme. *FEBS Letters*, *382(1-2)*, 213-217.

Erguder, İ. B., Avci, A., Devrim, E., & Durak, I. (2007). Effects of cooking techniques on antioxidant enzyme activities of some fruits and vegetables. *Turkish Journal of Medical Sciences*, *37(3)*, 151-156.

Feng, Q., Kim, J. H., Omiyale, W., Bešević, J., ... & Lacey, B. (2022). Raw and cooked vegetable consumption and risk of cardiovascular disease: a study of 400,000 adults in UK biobank. *Frontiers in Nutrition*, *9*, 831470.

Ferreira, V. B., da Silva, T. T. C., Couto, S. R. M., & Srur, A. U. O. S. (2015). Total phenolic compounds and antioxidant activity of organic vegetables consumed in Brazil. *Food and Nutrition Sciences*, *6(9)*, 798-804.

Goetz, M. E., Judd, S. E., Hartman, T. J., McClellan, W., ... & Vaccarino, V. (2016). Flavanone intake is inversely associated with risk of incident ischemic stroke in the reasons for geographic and racial differences in stroke (REGARDS) Study. *The Journal of Nutrition*, *146(11)*, 2233-2243.

Hwang, J. Y., Kim, Y., Lee, H. S., Park, E., ... & Lee, M. (2022). The development of resources for the application of 2020 dietary reference intakes for Koreans. *Journal of Nutrition and Health*, *55(1)*, 21-35.

Jayedi, A., Soltani, S., Abdolshahi, A., & Shab-Bidar, S. (2020). Healthy and unhealthy dietary patterns and the risk of chronic disease: an umbrella review of meta-analyses of prospective cohort studies. *British Journal of Nutrition, 124(11)*, 1133-1144.

Kalmpourtzidou, A., Eilander, A., & Talsma, E. F. (2020). Global vegetable intake and supply compared to recommendations: a systematic review. *Nutrients, 12(6)*, 1558.

Kardum, N., Takić, M., Šavikin, K., Zec, M., ... & Konić-Ristić, A. (2014). Effects of polyphenol-rich chokeberry juice on cellular antioxidant enzymes and membrane lipid status in healthy women. *Journal of Functional Foods*, *9*, 89-97.

Kim, S. Y., Freeland-Graves, J. H., & Kim, H. J. (2021). Twenty-year trends in vegetable consumption by preparation method and eating location for Korean population from 1998 to 2017. *British Journal of Nutrition, 126(5)*, 747-756.

Kim, Y. J., Park, M. Y., Chang, N., & Kwon, O. (2015). Intake and major sources of dietary flavonoid in Korean adults: Korean National Health and Nutrition Examination Survey 2010-2012. *Asia Pacific Journal of Clinical Nutrition, 24(3)*, 456-463.

Lee, S. J., Jang, H. L., Shin, S. R., & Yoon, K. Y. (2012). Quality characteristics of apple juice according to the sterilization methods. *Korean Journal of Food Preservation, 19(2)*, 178-184.

Lim, J., Lee, Y., Shin, S., Lee, H. W., ... & Kang, D. (2018). An association between diet quality index for Koreans (DQI-K) and total mortality in Health Examinees Gem (HEXA-G) study. *Nutrition Research and Practice, 12(3)*, 258-264.

Miller, V., Mente, A., Dehghan, M., Rangarajan, S., ... & Lopez, P. C. (2017). Fruit, vegetable, and legume intake, and cardiovascular disease and deaths in 18 countries (PURE): a prospective cohort study. *The Lancet, 390(10107)*, 2037-2049.

Miranda, A. M., Steluti, J., Fisberg, R. M., & Marchioni, D. M. (2016). Association between polyphenol intake and hypertension in adults and older adults: A population-based study in Brazil. *PloS One, 11(10)*, e0165791.

Mitjavila, M. T., & Moreno, J. J. (2012). The effects of polyphenols on oxidative stress and the arachidonic acid cascade. Implications for the prevention/ treatment of high prevalence diseases. *Biochemical Pharmacology, 84(9)*, 1113-1122.

Moreno, M. I. N., Isla, M. I., Sampietro, A. R., & Vattuone, M. A. (2000). Comparison of the free radical-scavenging activity of propolis from several regions of Argentina. *Journal of ethnopharmacology, 71(1-2)*, 109-114.

Priyadarshini, A., & Priyadarshini, A. (2018). Market dimensions of the fruit juice industry. *In Fruit juices* (pp. 15-32). Academic Press.

Scalbert, A., Manach, C., Morand, C., Rémésy, C., & Jiménez, L. (2005). Dietary polyphenols and the prevention of diseases. *Critical reviews in food science and nutrition*, *45(4)*, 287-306.

Shenoy, S. F., Kazaks, A. G., Holt, R. R., Chen, H. J., ... & Keen, C. L. (2010). The use of a commercial vegetable juice as a practical means to increase vegetable intake: a randomized controlled trial. *Nutrition journal*, *9*, 1-11.

Singleton, V. L., Orthofer, R., & Lamuela-Raventós, R. M. (1999). [14] Analysis of total phenols and other oxidation substrates and antioxidants by means of folin-ciocalteu reagent. *In Methods in Enzymology, 299,* pp. 152-178. Academic press.

Tekle, E. W., Sahu, N. P., & Makesh, M. (2015). Antioxidative and antimicrobial activities of different solvent extracts of moringa oleifera: an in vitro evaluation. *International Journal of Scientific and Research Publications, 5(5),* 1-12.

Vidal-Casanella, O., Moreno-Merchan, J., Granados, M., Nuñez, O., ... & Sentellas, S. (2022). Total polyphenol content in food samples and nutraceuticals: antioxidant indices versus high performance liquid chromatography. *Antioxidants, 11(2),* 324.

World Health Organization. (2003). *Diet, nutrition, and the prevention of chronic diseases: report of a joint WHO/FAO expert consultation, 916,* World Health Organization.

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