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Abstract	The purpose of this study was to evaluate and compare the antioxidant activities, and their contents, in grape juices prepared by various household juicers, and grape flesh (GF). The grape juices were prepared using a low-speed masticating (LSM) juicer, a high-speed centrifugal (HSC) juicer, and a blender (BLD). The total polyphenol, total flavonoid, total monomeric anthocyanin, and vitamin C contents were highest in the LSM grape juice, and decreased in the order: LSM > BLD > HSC > GF. The antioxidant activities such as DPPH radical scavenging activity, and SOD-like activity were significantly higher in the LSM juice than in other juices and grape flesh. The antioxidant activities and the quality of grape juices were significantly affected by the household juicing method used, and an LSM juicer is strongly recommended for making healthy grape juice, rich in antioxidants.

Keywords (separated by '-')	Grape juice - Grape flesh - Low-speed masticating household juicer - Antioxidant content - Antioxidant activity
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Antioxidant activities of fresh grape juices prepared using various household processing methods

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Abstract The purpose of this study was to evaluate and compare the antioxidant activities, and their contents, in grape juices prepared by various household juicers, and grape flesh (GF). The grape juices were prepared using a low-speed masticating (LSM) juicer, a high-speed centrifugal (HSC) juicer, and a blender (BLD). The total polyphenol, total flavonoid, total monomeric anthocyanin, and vitamin C contents were highest in the LSM grape juice, and decreased in the order: LSM > BLD > HSC > GF. The antioxidant activities such as DPPH radical scavenging activity, and SOD-like activity were significantly higher in the LSM juice than in other juices and grape flesh. The antioxidant activities and the quality of grape juices were significantly affected by the household juicing method used, and an LSM juicer is strongly recommended for making healthy grape juice, rich in antioxidants.

Keywords Grape juice · Grape flesh · Low-speed masticating household juicer · Antioxidant content · Antioxidant activity

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Introduction

Free radicals can cause oxidative stress, and oxidative damage plays a significant pathological role in chronic diseases including cardiovascular diseases, cancer, diabetes mellitus, and hypertension. Antioxidants, including phenolic compounds, flavonoids, and carotenoids, can reduce the risk of oxidative damage by scavenging free radicals and oxygen, and chelating catalytic metals. It is well known that fruits and vegetables are major sources of antioxidants.

The grape is one such fruits consumed world-wide, and can be eaten raw (as table fruit), or in processed products such as wine, juice, and sauce among others [1, 2]. Grapes are a good natural source of antioxidants, containing many phytochemicals such as anthocyanin, catechin, epicatechin, resveratrol, and proanthocyanidin, and therefore have strong activity for scavenging free radicals [3]. Besides, these polyphenols are known to have anticarcinogenic, anti-inflammatory, and antiproliferative properties. Most grape phenolic antioxidants are located in the skin and seeds. The estimated polyphenol content is approximately 60–70% in grape seeds, 30% in the skin, and only 6% in the flesh [1, 4]. Resveraterols, anthocyanins, and catechins are present in grape skins, while procyanidins are concentrated in the seeds [1]. Notably, grape seeds contain approximately 20-fold more proanthocyanidins compared with grape skins [5]. The purple colors of grapes and red wines are attributed to anthocyanins, which seem to be significantly correlated with antioxidant properties [4].

Generally, table grapes are consumed after removal of the seeds and skins, which are rich in polyphenols. Therefore, the consumption of grape seeds and skins is very helpful for the intake of bioactive components. Fresh grape juice, directly squeezed from whole grapes using a

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juicer, has an advantage over the consumption of table grapes, since large quantities of the seeds and skins are included in the juice, and the nutritional value of grapes is significantly affected by processing conditions [6, 7]. The phenolic composition and antioxidant activities of grape juices can also change depending on the type of household juicer used [8].

In this study, we tried to determine and compare the antioxidant levels and activities in grape juices prepared using various household processing methods, as well as the consumption of grapes as table fruit without seeds and skins. The grape juices were prepared using a blender (BLD), a conventional juicer (high-speed centrifugal juicer, HSC juicer), and a screw-type juicer (low-speed masticating juicer, LSM juicer). While an HSC juicer grinds and filters the grapes with a flat blade disk rotating at a high speed of 8000–12,000 rpm, an LSM juicer squeezes the grapes with a vertical helical screw (auger), rotating at a low speed of approximately 40–80 rpm. Kim et al. [9] reported that tomato juice prepared using an LSM juicer was richer in antioxidant compounds compared with that produced using an HSC juicer, since destruction of the compounds by oxidation could be minimized as heat generation was negligible with a slow-speed rotating auger. From this result, it is expected that the antioxidant levels and activities in grape juices may be significantly affected by the type of household juicer used.

A large number of studies have been published on the antioxidant activities of grape juice and grape products, but there are limited reports of fresh grape juices prepared using various household processing methods [8]. The aim of this study is to evaluate and compare the antioxidant activities (focused on free radical scavenging activities), and the quality, of grape juices prepared using various household juicers, and the grape flesh without skin and seeds.

Materials and methods

Materials

The grapes (*Vitis labrusca*, Campbell Early) were obtained from a local market in Gimhae, Korea. Folin-Ciocalteu's reagent, tannic acid, pyrogallol, DL-dithiothreitol (DTT), L-ascorbic acid, 1,1-diphenyl-2-picrylhydrazyl (DPPH), dimethyl sulfoxide (DMSO), hydrogen peroxide, and fluorescein were purchased from Sigma-Aldrich (St. Louis, MO, USA). 2,2′-Azobis (2-methylpropionamidine) dihydrochloride (AAPH) was purchased from Wako Pure Chemical Industries, Ltd. (Osaka, Japan), and copper sulfate (II) pentahydrate was purchased from Kanto Chemical Co. (Chuo-ku, Tokyo, Japan). All organic solvents and other chemicals were of analytical grade or complied with the standards needed for cell culture experiments, or high performance liquid chromatography (HPLC) grade.

Preparation of grape juices and grape flesh

Grapes were detached from a bunch and washed with tap water before juice extraction. The HSC and LSM grape juices were prepared using an HSC juicer (SJ 600, Dongah Co., Ltd., Korea) and a vertical-type LSM juicer (SJ200B, Hurom Co., Ltd., Korea), respectively, according to the manufacturer's instructions. For BLD juice preparation, the same amount of water (1:1, w/w) was added to washed grapes before grinding for 5 min using a blender (HM-1600 PB, Hanil Co., Korea). The grape flesh (GF) was prepared from washed grapes by removing skins and seeds by hand. Each sample was used immediately in experiments, or freeze-dried just after sample preparation using a freeze-dryer (FDU-7003, Operon Co., Ltd., Korea) and kept at −20 °C before analysis.

Physicochemical analyses

The pH of grape juices was determined using a pH meter (AG 8603, Mettler Toledo, Schwerzenbach, Switzerland) at 25 ± 1 °C. Total soluble solids (TSS) were measured with a digital refractometer (Atago, PAL-1 digital refractometer, Tokyo, Japan). Titratable acidity (TA) of the grape juice was measured by titrating 100 mL of five-fold diluted juice to pH 8.3 with standardized 0.1 N NaOH. The TA was expressed as the percentage of citric acid per 100 mL of juice.

Analysis of total polyphenol content

Total polyphenol content was analyzed according to the Folin-Denis method with some modification [10]. A sample (0.1 g) of freeze-dried juice powder was dissolved in 10 mL of 80% MeOH, resuspended thoroughly by vortexing, and kept for 2 h at room temperature in the dark. After centrifuging the solution at 1000×*g* and 4 °C for 20 min, a supernatant (GJME) was collected. First, 0.2 mL of 50% Folin-Ciocalteu's reagent was added to 0.4 mL of properly diluted GJME and mixed well at room temperature. After 3 min, 0.4 mL of 2% Na_2CO_3 was added, and the mixture was incubated for 60 min at room temperature. The absorbance was measured at 750 nm using a spectrophotometer (Libra S22, Biochrom, Cambridge, England), and quantified from a calibration curve using tannic acid as a standard. All samples were analyzed in triplicate. Total polyphenol content was expressed as milligrams of tannic acid equivalents (TAE) per 100 mL juice.

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Analysis of total flavonoid content

Total flavonoid content was measured according to the method described by Zhishen with some modification [11]. First, 0.03 mL of 5% $NaNO_2$ was added to 0.4 mL of properly diluted GJME. After 5 min, 0.3 mL of 1% $AlCl_3$ was added to the mixture and incubated for 6 min at room temperature, before 0.2 mL of 1 M NaOH and 0.07 mL of deionized water were added sequentially. The absorbance of the mixture was measured at 510 nm using a spectrophotometer, and quantified using quercetin as a standard. All samples were analyzed in triplicate. Total flavonoid content was expressed as milligrams of quercetin equivalents (QE) per 100 mL juice.

Analysis of total monomeric anthocyanin

Anthocyanin content was determined using the method described by Lee et al. [12], with some modification. A sample (0.2 g) of freeze-dried juice powder was dissolved in 3 mL of deionized water and kept for 3 h at 4 °C. An aliquot of supernatant was collected by centrifugation at 850×*g* and 4 °C for 20 min. Then, 0.1 mL of the sample was added to 0.9 mL of pH 1.0 buffer (0.2 M KCl + 0.2 M HCl) or 0.9 mL of pH 4.5 buffer (0.02 M sodium acetate + 0.1 M citric acid) and incubated for 20 min. The absorbance of each solution was measured at 520 nm and 700 nm, respectively, using a spectrophotometer. The content of total monomeric anthocyanin was calculated from a molecular extinction coefficient (26,900 L/cm·mol) of cyanidine-3-glucoside and expressed as milligrams of cyanidine-3-glucoside equivalents (CE) per 100 mL juice using the following equation. Analyses were conducted in triplicate.

$$\text{Total monomeric anthocyanin content (mg CE/100 mL)} = \frac{A \times ME \times SC \times 150 \times 100}{\varepsilon \times L}$$

where $A = \{(A_{520nm} - A_{700nm})$ at pH1.0$\} - \{(A_{520nm} - A_{700nm})$ at pH4.5$\}$, MW is the molecular weight of cyanidine-3-glucoside (449.2 g/mol), SC is the solid content of grape juice (g/mL), ε is the molecular extinction coefficient of cyanidine-3-glucoside (26,900 l/cm·mol), and L is the cell path length (1 cm).

Analysis of vitamin C content

Vitamin C (L-ascorbic acid) content was analyzed using the method described by Furusawa with some modification [13]. A sample (0.1 g) of freeze-dried juice powder was dissolved in 1 mL of 2 mg/mL DTT in 2% acetic acid, and stored for 3 h at 4 °C in the dark, in order to reduce dehydroascorbic acid to ascorbic acid. The supernatant was analyzed by HPLC (Ultimate 3000, Dionex, Sunnyvale, CA, USA) after centrifugation at 1000×*g* and 4 °C for 20 min. Each sample was filtered through a 0.45 μm membrane filter (Millipore Corp., Bedford, MA, USA) before injection. L-Ascorbic acid was separated using a C_{18} column (Gemini 5 μm C18, 250 × 4.6 mm; Phenomenex, Torrance, CA, USA) and 2% acetic acid was used as the mobile phase, in isocratic mode with a flow rate of 1 mL/min. The peaks were monitored using a photodiode array detector (PDA, Dionex, Sunnyvale, CA, USA) at 254 nm. The content of vitamin C was calculated from the peak area corresponding to L-ascorbic acid using a calibration curve of authentic L-ascorbic acid. Analyses were performed in triplicate.

Analysis of DPPH radical scavenging activity

DPPH radical scavenging activity was assayed based on the method described by Blois with some modification [14]. Briefly, 0.2 mL of the properly diluted sample (GJME) was added to 0.8 mL of 0.3 mM DPPH solution in 80% ethanol, and incubated in the dark for 10 min at room temperature. The radical scavenging activity (%) was calculated from the decrease in the absorbance measured at 517 nm using a spectrophotometer. The results were expressed as the amount of juice (mg of dry weight) which is required to scavenge 50% of DPPH radical (IC_{50}). Distilled water was used as a control.

$$\text{DPPH radical scavenging activity (\%)} = \left(1 - \frac{\text{Abs. of sample}}{\text{Abs. of control}}\right) \times 100$$

Analysis of SOD-like activity

Superoxide dismutase (SOD)-like activity was analyzed using the method described by Murklund [15]. Briefly, 0.65 mL of 50 mM Tris–HCl buffer (pH 8.7) and 0.1 mL of 7.2 mM pyrogallol were added sequentially to 0.1 mL of the properly diluted sample (GJME) and the mixture was incubated for 10 min at 25 °C. SOD-like activity (%) was assayed by measuring superoxide anion radical inhibition at 420 nm using a spectrophotometer. Distilled water was used as a control. The results were expressed as the amount of juice (μg of dry weight) required to reduce 50% of the superoxide anion (IC_{50}).

$$\text{SOD - like activity (\%)} = \left(1 - \frac{\text{Abs. of sample}}{\text{Abs. of control}}\right) \times 100$$

Oxygen radical absorbance capacity (ORAC) assay

The ORAC assay was performed on the freeze-dried samples as described by Kurihara et al. [16]. Peroxyl

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radical was generated using AAPH (20 mM) and fluorescein (40 nM) was used as a target of free radical attack. The decay of fluorescence was measured using a multifunctional plate reader (GENios; Tecan Trading AG, Grödig, Austria) with fluorescent filters (excitation wavelength: 485 nm and emission wavelength: 535 nm). The blank-corrected area under the fluorescence decay curve for each sample was plotted against the Trolox concentrations, and the ORAC values were expressed as μM of trolox equivalents (μM TE).

Statistical analysis

All data are presented as mean ± SD. The mean values were compared using one-way analysis of variance (ANOVA) followed by Duncan's multiple range tests (SPSS, version 19). Significance was accepted as a probability of 5% and was defined as $p < 0.05$.

Results and discussion

Physicochemical properties

The general physicochemical properties of grape juices prepared by various household methods and grape flesh were shown in Table 1. The yield of the LSM juicer was 79.1%, which was better than that of the HSC juicer (45.0%). The difference in yield is caused by the different juice extracting mechanisms, and a similar result was obtained when preparing tomato juice [9]. The TSS of the grape juices ranged from 13.8 to 14.4. The TA of the GF and the LSM juice were higher than those of the HSC and BLD juices. Higher TA in grape juice is known to produce better sensory attributes, associated with its characteristic flavor and astringency [17]. While the pH of LSM and HSC grape juices, and GF, was similar and ranged from 3.20 to 3.23, BLD juice showed the highest pH of 3.34. Aguilar-Rosas et al. [18] reported that the pH of juice was directly related to temperature. Heat generation during blender operation seems to be one of reasons for the high pH. Maintaining a low pH also helps to prevent the growth of pathogenic microorganisms in the fruit juice [18].

Total polyphenol content

Polyphenols are grouped into flavonoids, phenolic acids, and phenolic compounds in plants, and are known to have antioxidant effects in vitro and in vivo [1]. Since the antioxidant activities of plant extracts are closely related with their polyphenol content, extracts containing high-level of polyphenols have a great importance as natural antioxidants [19]. Phytochemicals, especially phenolics in fruits and vegetables, are major bioactive compounds known for their health benefits [4]. In particular, grape skins and seeds are reported to be abundant in polyphenols and exert potent free radical scavenging effects by converting radicals into stable compounds to stop radical-mediated reactions [1]. Total polyphenol contents of grape juices produced using various household methods are shown in Fig. 1(A). These results indicated that grape juices were rich in polyphenols, but the contents were quite different according to the juicing methods. While total polyphenol content of the LSM grape juice (326.8 ± 1.6 mg TAE/100 mL) was the highest, that of GF (consumption of fresh grapes after removal of skins and seeds) was the lowest (47.1 ± 0.4 mg TAE/100 mL) among the samples, as expected. Xu et al. [2] reported that grape skins and seeds were rich in phenolic compounds, and that the seeds contained higher levels than the skins. Total polyphenol content of the HSC grape juice (90.3 ± 1.4 mg TAE/100 mL) was significantly lower compared with that of the LSM grape juice. This result is due to the different extraction mechanisms of the juicers. The flat blade disk rotating at a high speed (8000–12,000 rpm), causes deflection of a considerable amount of the grape to waste, and therefore the extraction of polyphenols from grape skins and seeds is insufficient [9]. Although a blender ground all parts of the grape without loss during the juicing process, the total polyphenol content of BLD juice was

Table 1 Yields, total soluble solids (TSS), titratable acidity (TA) and pH of grape juices prepared using various household processing methods, and grape flesh

	LSM	HSC	BLD	GF
Yield (%)	79.1	45.0	100.0	44.6
TSS (°Brix)	14.3 ± 0.1[1a]	14.4 ± 0.1[a3]	13.8 ± 0.1[b]	13.7 ± 0.1[b]
TA (%)	0.32 ± 0.00[b]	0.29 ± 0.00[c]	0.20 ± 0.01[d]	0.35 ± 0.00[a]
pH	3.22 ± 0.01[b]	3.20 ± 0.01[c]	3.34 ± 0.01[a]	3.23 ± 0.01[b]

Grape juices were prepared using a low-speed masticating juicer (LSM), a high-speed masticating juicer (HSC), and a blender (BLD). Grape flesh (GF) was prepared by removing seeds and skins from whole grapes

[1] The results are expressed as mean ± SD ($n = 3$)

[3] Values with different letters in the same column are significantly different, $p < 0.05$

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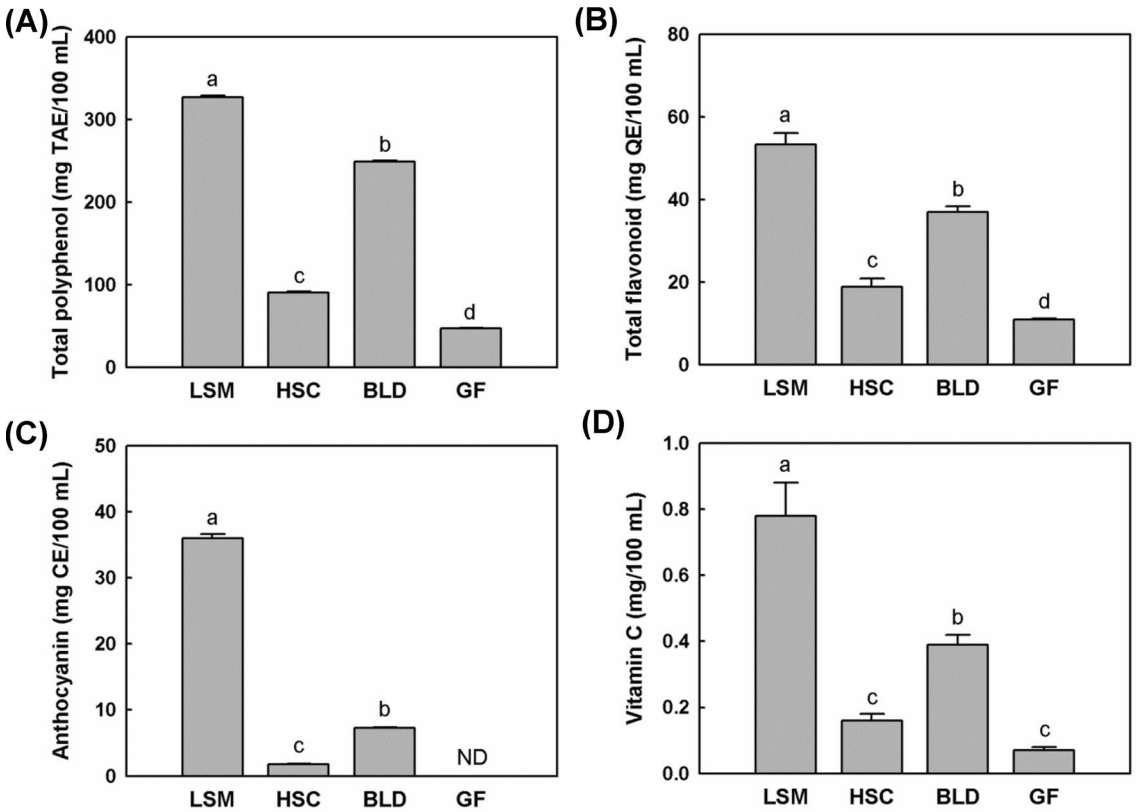

Fig. 1 The antioxidant contents of grape juices and grape flesh. (**A**) Total polyphenol, (**B**) total flavonoid, (**C**) total monomeric anthocyanin, and (**D**) vitamin C. Grape juices were prepared using a low-speed masticating juicer (LSM), a high-speed masticating juicer (HSC), and a blender (BLD). Grape flesh (GF) was prepared by removing seeds and skins from whole grapes. *TAE* tannic acid equivalents; *QE* quercetin equivalents; and *CE* cyanidine-3-glucoside equivalents. The results are expressed as mean ± SD ($n = 3$). *Different superscripts* signify significant differences ($p < 0.05$) by Duncan's multiple range test. *ND* not detected

lower than that of LSM juice. Since oxidation was accelerated by the blender, due to heat generated by the high-speed rotating blade, the polyphenols were more easily destroyed than when using the LSM juicer. Also, BLD juice showed higher polyphenol oxidase (PPO) activity than LSM juice, which could be one of the reasons for the low polyphenol content (data not shown). In a similar study by Burin et al. [8] on total polyphenol contents in grape juices using the Folin–Ciocalteu method, the results for homemade, commercial, and organic grape juices ranged between 111.7 and 343.3 mg GAE/100 mL. They suggested that the differences come from juice processing techniques, including extraction type, temperature, and addition of enzymes. Previous study with tomato juices prepared using different household extraction methods showed similar results as with grape juices [9]. These results suggest that, from the view point of polyphenol uptake, the consumption of fresh, whole grape juice is better than that of grape flesh without seeds and skins, and an LSM juicer was more effective for preparation of grape juice rich in polyphenols, than an HSC juicer or a blender.

Total flavonoid content

Flavonoids are a group of polyphenols, consisting of a C6–C3–C6 flavone skeleton, with a three-carbon bridge cyclized with oxygen between the phenyl groups, and have been shown to inhibit tumor growth, NF-κB activation, and cytokine synthesis [20]. Flavonoids are widely distributed in fruits and vegetables. In particular, grapes are known to be rich in several flavonoids including resveratrol, anthocyanin, kaempferol, myricetin, and quercetin [2, 21]. Total flavonoid contents of fresh grape juices, produced using household juicers, ranged from 18.8 ± 2.1 for HSC juice, to 53.3 ± 2.8 mg QE/100 mL for LSM juice (Fig. 1(B)). The GF showed the lowest total flavonoid content. The results showed a similar trend to total polyphenol contents as discussed above. However, the difference in the total

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flavonoid contents among the juices was lower than that in the total polyphenol contents.

Total monomeric anthocyanin content

Monomeric anthocyanin content, determined by the structural transformation that occurs when pH changes, is also known as the total anthocyanin content. Anthocyanin is highly pigmented in many red, purple, and blue flowers, fruits, and vegetables, especially in grapes and berries. The most abundant anthocyanins in grape juices were noted as cyanidin-3-*O*-glucoside, delphinidin-3-*O*-glucoside, and malvidin-3-*O*-glucoside [22]. Anthocyanin is the major contributor to the free radical scavenging activity of red grapes [4]. The total anthocyanin contents of grape juices and GF are shown in Fig. 1(C). The anthocyanin content in LSM grape juice was significantly higher than those of other juices ($p < 0.05$). Interestingly, the LSM grape juice (36.0 ± 0.6 mg CE/100 mL) showed about 20-fold higher total anthocyanin content than HSC grape juice (1.8 ± 0.1 mg CE/100 mL). The BLD juice also showed a low total anthocyanin content (7.3 ± 0.1 mg CE/100 mL). Many studies reported that anthocyanins are unstable compounds, and easily susceptible to degradation through factors such as light, pH, oxygen, enzymes, and temperature during storage, and especially during heat processing [22, 23]. Therefore, the anthocyanins in BLD juices were supposed to be destroyed due to the enhanced oxidation caused by the relatively high temperature and the action of PPO. Tiwari et al. [22] reported that total anthocyanin was 15.8 mg/100 mL in ozonated grape juice, which was lower than that of LSM juice in this study. The differences seem to be caused by various factors such as grape species and the processing method. These results indicated that the LSM juicer was suitable for the extraction of anthocyanin from grapes, with minimum degradation. As expected, when we have fresh grapes, after removal of skins and seeds (GF), most of the anthocyanins are also discarded together with skins and seeds.

Vitamin C contents

Vitamin C reduces the initial quinone formed by PPO enzymes to the original diphenol, preventing the process that leads to browning [24]. Therefore, vitamin C has a positive effect on color during juice making. Figure 1(D) shows vitamin C contents of the grape juices produced using various household juicers, and the grape flesh. The results were similar to those for polyphenols, flavonoids, and anthocyanins. The content of vitamin C in LSM grape juice was the highest, and decreased in the order: LSM > BLD > HSC > GF with a range between 0.07 ± 0.01 and 0.78 ± 0.10 mg/100 mL. The lower contents in BLD and HSC juices were supposed to be mainly attributed to the thermolysis and oxidation of ascorbic acid, due to grinding with high-speed rotating blades [25]. We can consume greater than tenfold more vitamin C with LSM juice, compared with grape flesh without seeds and skins.

DPPH radical scavenging activity

DPPH radical scavenging activity was measured by detecting reduction of DPPH free radicals after electron transfer from antioxidants, a widely used test of free-radical scavenging ability [14]. The DPPH radical scavenging activities (IC_{50}) of the grape juices prepared using various juicing methods, ranged from 0.27 ± 0.01 to 3.81 ± 0.16 mg (Fig. 2(A)). The IC_{50} values of LSM and BLD grape juices were the lowest, that is, the DPPH radical scavenging activity of both juices was better than that of other samples. Higher antioxidant contents, such as total polyphenol, total flavonoid, vitamin C, and total anthocyanin, in LSM and BLD juices seems to be one of the major reasons for this result, which is in agreement with other studies [26]. The similar results were observed as tomato juices prepared using different household extraction methods among which LSM juicer showed lower DPPH radical scavenging activity than HSC juicer [9].

SOD-like activity

SOD-like activity was measured by elimination of superoxide, a kind of active oxygen. Among the samples, the LSM grape juice showed the highest SOD-like activity, with the lowest IC_{50} value of 3.9 ± 0.5 μg (Fig. 2(B)). The other three samples showed similar activities. Iwasawa et al. [27] noted that the main candidate for SOD-like activity was polyphenol rather than vitamin C in fruits. The SOD-like activities of the samples in this study were higher than those reported by Dani et al. [28]. This may be due to the use of different grape cultivars and sample preparation methods (fresh vs. freeze-dried samples).

Oxygen radical absorbance capacity (ORAC)

The ORAC assay, which is recommended as the standard method for determining both the antioxidant activity of food, and human plasma antioxidant capacity [29, 30], was adapted in this study. The ORAC values of grape juices prepared using various household processing methods are shown in Fig. 3. Concordant with the results of total polyphenols, flavonoids, anthocyanins, vitamin C, and DPPH radical scavenging activity, the grape juices prepared using the blender (BLD) and the LSM juicer showed the highest ORAC values (2.78 ± 0.03 and

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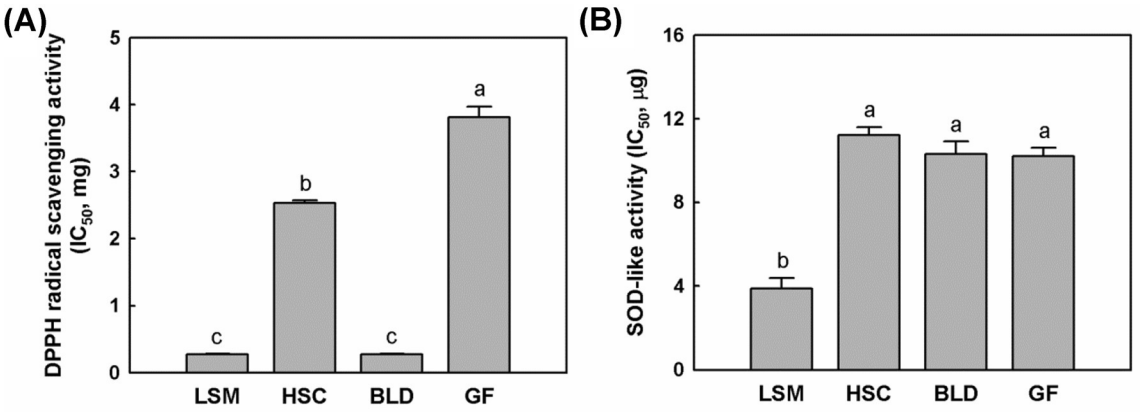

Fig. 2 The antioxidant activities of grape juices and grape flesh. (**A**) DPPH radical scavenging activity and (**B**) SOD-like activity. Grape juices were prepared using a low-speed masticating juicer (LSM), a high-speed masticating juicer (HSC), and a blender (BLD). Grape flesh (GF) was prepared by removing seeds and skins from whole grapes. IC_{50}: the amount of juice (dry weight) required for 50% reduction of DPPH radical or superoxide anion radical. The results are expressed as mean ± SD ($n = 3$). *Different superscripts* signify significant differences ($p < 0.05$) by Duncan's multiple range test

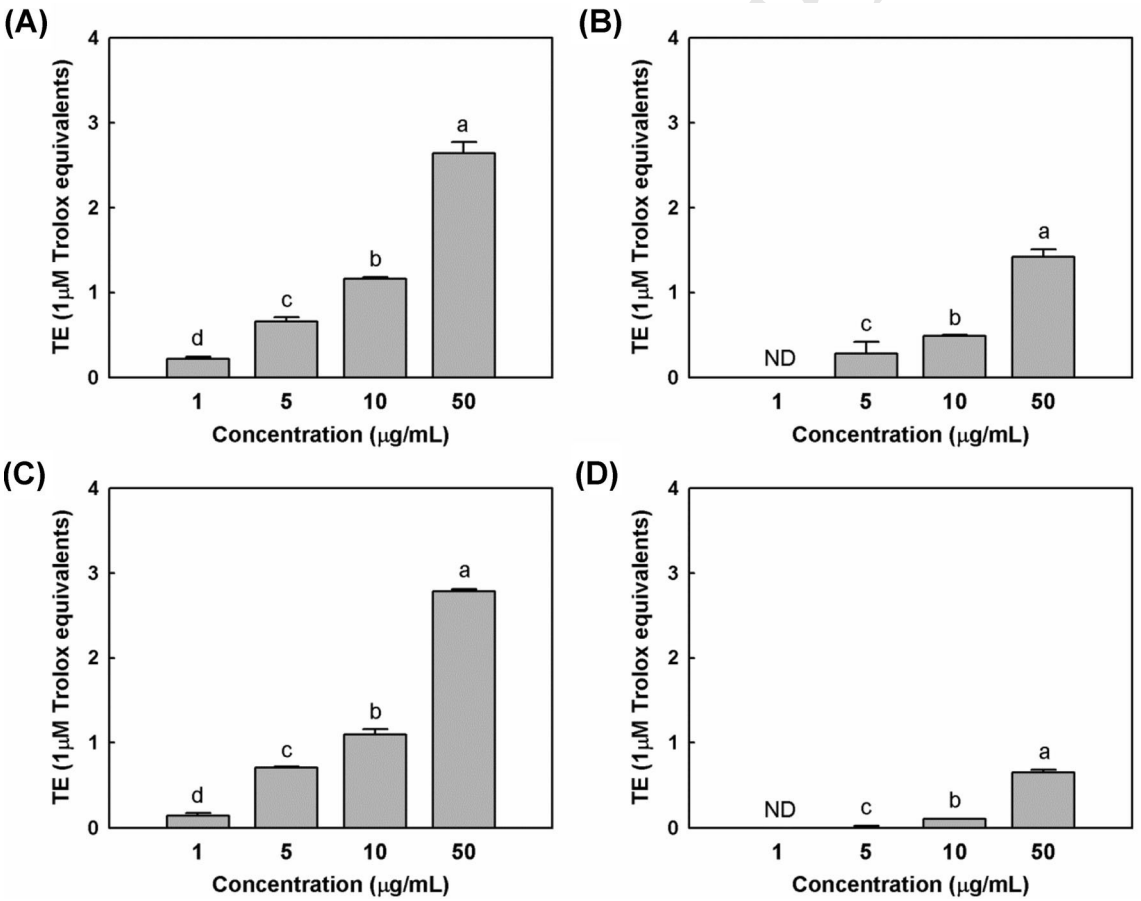

Fig. 3 Oxygen radical absorbance capacity (ORACROO·) values of grape juices prepared using various household processing methods, and grape flesh. (**A**) Low-speed masticating juicer (LSM); (**B**) high-speed masticating juicer (HSC); (**C**) blender (BLD); and (**D**) grape flesh (GF). The results are expressed as mean ± SD ($n = 3$). For all the bars of each sample, *different superscripts* signify significant differences ($p < 0.05$) by Duncan's multiple range test. ND: Not detected

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2.64 ± 0.13 μM TE at the concentration of 50 μg/mL, respectively), followed by grape juices using the HSC juicer (1.42 ± 0.09 μM TE at 50 μg/mL). The raw grape flesh showed the lowest ORAC value (0.65 ± 0.03 μM TE at 50 μg/mL). Dávalos et al. [31] reported that the ORAC value could be changed according to their phenolic contents among red and white grape juices. It seems that the higher contents of total polyphenol and total flavonoid in LSM and BLD made a positive contribution to higher ORAC values.

Our research demonstrated that the antioxidant activities, and the quality of grape juices, were significantly affected by the household juicing method used. Antioxidant activities and nutritional properties of LSM grape juice were the highest, compared to those of other grape juices. Also, the consumption of whole grape juice is more beneficial to health than that of grape flesh because we can take more antioxidants from grape skins and seeds in whole grape juice. Therefore, an LSM juicer is strongly recommended for making healthy grape juice rich in antioxidants.

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Compliance with ethical standards

Conflict of interest The authors declare no conflict of interest.

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