Journal of Medical Sciences

ISSN 1682-4474

science alert

ANSInet
an open access publisher
http://ansinet.com

Research Paper

J. Med. Sci., 13 (8): 708-715
15th November, 2013
DOI: 10.3923/jms.2013.708.715

Beverage Made from Fully Ripened Silver Vine [*Actinidia polygama* (Sieb. et Zucc.) Planch. ex Maxim.] Berries Possesses Some Health-promoting Potential

[1,2,3]Takeshi Nagai, [4]Norihisa Kai, [4]Yasuhiro Tanoue and [5]Nobutaka Suzuki

This study investigated chemical parameter of beverage made from fully ripened silver vine berries and the health-promoting property. The beverage was rich in phenolic compounds and vitamin C as follows: 283.5 and 185.3 ($\mu g\ mL^{-1}$), respectively. According to sensory tests, colour, taste and aroma (Brix:acid ratio), body, and overall acceptability of beverage were observed highly acceptable when the concentrated beverage-hot water were blended in the ratio of 20:80. Moreover, this beverage possessed the strongest and beneficial potential, which had higher inhibitory effects of lipid peroxidation, scavenging effects on superoxide anion radicals, hydroxyl radicals, and 1,1-diphenyl-2-picrylhydrazyl (DPPH) radicals, and ACE inhibitory effects in comparison with ascorbic acid and α-tocopherol used as controls. Our present findings suggests that beverage made from fully ripened silver vine berries may be useful for prevention of chronic diseases associated with free radical induced injury, coronary heart disease, high blood pressure and cancer etc.

Key words: Silver vine, fully ripened berry, beverage, functional property

JMS (ISSN 1682-4474) is an International, peer-reviewed scientific journal that publishes original article in experimental & clinical medicine and related disciplines such as molecular biology, biochemistry, genetics, biophysics, bio-and medical technology. JMS is issued eight times per year on paper and in electronic format.

For further information about this article or if you need reprints, please contact:

Takeshi Nagai
Graduate School of Agricultural Sciences, Yamagata University, Yamagata 9978555, Japan

Tel.: +81-868-26-6355

[1]Graduate School of Agricultural Sciences, Yamagata University, Yamagata 9978555, Japan
[2]The United Graduate School of Agricultural Sciences, Iwate University, Iwate 0208550, Japan
[3]Prince of Songkla University, Songkhla 90112, Thailand
[4]National Fisheries University, Yamaguchi 7596595, Japan
[5]Nagoya Research Institute, Aichi 4701131, Japan

ANSInet
Asian Network for Scientific Information

INTRODUCTION

Functional foods could potentially be used for improved health or well-being in a range of areas, including cardiovascular system, gastrointestines, growth, metabolism, defense against free radical oxidation and to enhance psychological functions. There is a wide range of products and developments that provide examples for the changing relationship between food and health because of the increasing attention to the health-diet interaction.

Tea is one of beverages that is consumed all over the world and the production is about 4 million tons in 2009. Traditionally, it is well known that tea shows the physiological functions such as improvement of blood flow and resistance to diseases and detoxification (Balentine *et al*., 1997). Moreover, it is reported pharmacological characteristics of tea including antioxidative activity (Matsuzaki and Hara, 1985), antimutagenic (Yen and Chen, 1994) and anticancer (Katiyar *et al*., 1992) effects. In recent years, many kinds of tea are produced and selling in the market. Among them, teas made from fruits such as citron tea, kumquat tea, lemon tea, ume tea, grape tea and Chinese quince tea are very popular with everybody because of sweet and easy to drink in comparison with tea.

Silver vine [*Actinidia polygama* (Sieb. et Zucc.) Planch. ex Maxim.] is a vined medicinal plant and is a native plant in the fields and mountain in all parts of Japan, China, Korea, Sakhalin and the South Lurils. It belongs to the same Actinidiaceae as kiwifruit and it comes into flower in August and into bearing in October. Until now, unripened berries have been used as materials such as pickles (preservation with salt, pickled with miso) and liquors. On the other hand, ripened berries have been used for the processing of jam, dried fruits and puree etc. However, the annual production of silver vine berries is limited and it is not well known to use as edible fruits. So, it is very interesting to develop the effective use of low utilization of resources such as silver vine berries.

As consumers have become increasingly concerned about their health, their selection of products and services has been impacted. It has been assumed that increasing consumers nutrition knowledge well lead to changes in attitudes and benefits and in turn their food selection will be impacted (Tepper *et al*., 1997). Specific health promoting marketing strategies has been developed to reach consumers. The berries of silver vine are referred to as foodstuff that contains a large amount of vitamin C. The present study aims to prepare beverage made from fully ripened silver vine berries as one of an enhanced value-added functional foods and to clarify the health-promoting effect of the beverage. It may be expected the prevention of life-style related diseases as cancer and hypertension by continued drinking of beverage made from the berries.

MATERIALS AND METHODS

Materials: Fully ripened silver vine berries were harvested in Abashiri City, Hokkaido, Japan and transported to our laboratory. The berries were stored at -30°C until used. Angiotensin I-converting enzyme (ACE) from bovine lung (1U), 2,2'-azobis(2-amidinopropane)dihydrochloride (AAPH), α,α'-dipyridyl, chlorogenic acid, 2-deoxy-D-ribose, ethylenediaminetetraacetic acid disodium salt (EDTA), 1,1-diphenyl-2-picrylhydrazyl (DPPH), ethyl acetate for spectrochemical analysis grade, hippuryl-L-histidyl-L-leucine as substrate peptide, linoleic acid, nitroblue tetrazolium salt (NBT), α-tocopherol and xanthine were purchased from Wako Chemicals Co. Ltd. (Osaka, Japan). Xanthine oxidase from butter milk (XOD; 0.33U mg^{-1} powder) was from Oriental Yeast Co. Ltd. (Tokyo, Japan). All other chemicals were of analytical grade.

Preparation of the beverage made from fully ripened silver vine berries: After fully ripened silver vine berries were thawed at half, the calyces were removed and then washed with water. These berries were wiped of the water with a cloth, weighed and added an equivalent weight of crystal sugar (Pearl Ace Co. Ltd., Tokyo, Japan) in the bottle. After extracting in the dark condition at room temperature for 2 weeks with occasional agitation, the beverage was used for the following tests.

Proximate compositions of the beverage made from fully ripened silver vine berries: Sugar content and pH of the beverage were measured using a hand-held refractometer (H-80; Atago Co. Ltd., Tokyo, Japan) and a pH meter (PHL-40; DKK Co. Ltd., Tokyo, Japan), respectively. Colour analysis was performed using a Minolta spectrophotometer M-3500d (Tokyo, Japan) with illuminant D65 was used. Colour was recorded using a CIE L * a* b* colour space; L* [lightness (0 = black, 100 = white)], a* (-a = greenness, +a = redness) and b* (-b = blueness, +b = yellowness). Total phenolic components were measured at 760 nm using chlorogenic acid as standard (Slinkard and Singleton, 1977). Total vitamin C content was determined using the α,α'-dipyridyl method (The Vitamin Society of Japan, 1990).

Sensory evaluation: The beverage made from fully ripened silver vine berries was evaluated for sensory

qualities on the basis of colour (appearance), taste and aroma, body and overall acceptability by a panel of 10 judges on a 7-point Hedonic scale (Amerine *et al*., 1965). The sensory tests of beverages were performed after the dilution of the beverage by hot water at 80°C.

Antioxidative activity: Antioxidative activity of the beverage made from fully ripened silver vine berries was measured in a linoleic acid oxidation system described by Nagai and Nagashima (2006). A 0.083 mL of the beverage and 0.208 mL of 0.2 M sodium phosphate buffer (pH 7.0) were mixed with 0.208 mL of 2.5% (w/v) linoleic acid in ethanol. The preoxidation was initiated by the addition of 20.8 μL of 0.1 M AAPH and carried out at 37°C for 200 min in the dark. The degree of oxidation was measured according to the thiocyanate method for measuring peroxides by reading the absorbance at 500 nm after colouring with $FeCl_2$ and ammonium thiocyanate. Ascorbic acid (1 and 5 mM) and α-tocopherol (1 mM) were used as positive control. Distilled water was used as negative control.

Superoxide anion radical scavenging activity: Effect of superoxide anion radical was evaluated as described by Nagai and Nagashima (2006). This system contained 0.48 mL of 0.05 M sodium carbonate buffer (pH 10.2), 0.02 mL of 0.15% of BSA, 0.02 mL of 3 mM EDTA, 0.02 mL of 0.75 mM NBT, 0.02 mL of 3 mM xanthine and 0.02 mL of the beverage. After preincubation at 25°C for 10 min, the reaction was started by adding 6 mU XOD and carried out at 25°C for 20 min. The reaction was stopped by adding 0.02 mL of 6 mM CuCl. The solution was centrifuged at 12,000 rpm for 5 min and the absorbance of the reaction mixture was measured at 560 nm and the inhibition rate was calculated by measuring the amount of formazan that was reduced from NBT by superoxide. Ascorbic acid (1 and 5 mM) and α-tocopherol (1 mM) were used as positive control. Distilled water was used as negative control. The IC_{50} value was defined as the concentration of the beverage required to inhibit 50% of superoxide anion radical activity.

Hydroxyl radical scavenging activity: The effect of hydroxyl radical in the beverage made from fully ripened silver vine berries was assayed using the deoxyribose method (Nagai and Nagashima, 2006). The reaction mixture contained 0.45 mL of 0.2 M sodium phosphate buffer (pH 7.0), 0.15 mL of 10 mM 2-deoxy-D-ribose, 0.15 mL of 10 mM $FeSO_4$-EDTA, 0.525 mL of distilled water and 0.075 mL of the beverage in an Eppendorf tube. The reaction was started by the addition of 0.15 mL of 10 mM H_2O_2. After incubation at 37°C for 4 h, the reaction was stopped by adding 0.75 mL of 1.0% (w/v) of 2-thiobarbituric acid in 50 mM NaOH and 0.75 mL of 2.8% (w/v) trichloroacetic acid. The solution was boiled for 10 min and then cooled in water. The solution was centrifuged at 12,000 rpm for 5 min and the absorbance of the supernatants was measured at 520 nm. Hydroxyl radical scavenging activity was evaluated as the inhibition rate of 2-deoxy-D-ribose oxidation by hydroxyl radicals. Ascorbic acid (1 and 5 mM) and α-tocopherol (1 mM) were used as positive control. Distilled water was used as negative control. The IC_{50} value was defined as the concentration of the beverage required to inhibit 50% of hydroxyl radical activity.

DPPH radical scavenging activity: The effect of DPPH radical was measured as described by Nagai and Nagashima (2006). The assay mixture contained 0.03 mL of 1.0 mM of DPPH radical solution in ethanol, 0.24 mL of 99% of ethanol and 0.03 mL of the beverage. The mixture was rapidly mixed and scavenging capacity was measured by monitoring the decrease in absorbance at 517 nm. Ascorbic acid (1 and 5 mM) and α-tocopherol (1 mM) were used as positive control. Distilled water was used as negative control. The IC_{50} value was defined as the concentration of the beverage required to inhibit 50% of DPPH radical activity.

ACE inhibitory activity: The ACE inhibitory activity of the beverage made from fully ripened silver vine berries was performed as described by Nagai and Nagashima (2006). Twenty five microliters of the beverage and 75 μL of 0.1 M sodium borate buffer (pH 8.3) containing 5.83 mM hippuryl-L-histidyl-L-leucine as substrate and 1.0 M NaCl in an Eppendorf tube were preincubated at 37°C for 5 min. The mixture was incubated with 25 μL of 0.1 M sodium borate buffer (pH 8.3) containing 1 mU ACE and 1.0 M NaCl at 37°C for 60 min. By adding 125 μL of 1.0 M HCl the reaction was stopped. The resulting hippuric acid was extracted with 750 μL of ethyl acetate by violently mixing for 15 sec. After centrifugation at 6,000 rpm for 3 min, 500 μL of the upper layer was transported into the other tube and evaporated at 80°C for 2 h. The hippuric acid was dissolved in 500 μL of distilled water and then the absorbance was measured at 228 nm. The IC_{50} value was defined as the concentration of the beverage required to inhibit 50% of the ACE activity.

Statistical analysis: Each assay was repeated 3 times independently and the results were reported as Means±SD.

RESULTS

Chemical parameter of the beverage made from fully ripened silver vine berries: The beverage was successfully prepared from fully ripened silver vine berries. Chemical parameter of the beverage was investigated. As a result, specific gravity, sugar content and pH of the beverage were 1.291, 50.8 (Brix % at 20°C) and 5.32 (20°C), respectively (Table 1). The colour of the beverage correlated with that of berries was as amber (colour parameter L* = 76.85, a* = 2.59, b* = 41.07). The contents of total phenolic components and total vitamin C were about 283.5 and 185.3 μg mL^{-1}, respectively (Table 1). That is, fully ripened silver vine berries could produce the beverage of benefits to human health, with high contents of phenol components and vitamin C. In other words, it is expected to prepare the beverage to have high antioxidative activity, free radical scavenging activity, coronary heart disease prevention and anticancer activity, etc using fully ripened silver vine berries. It is known that fruits such as garden strawberry (62 mg 100 g^{-1} wet berries), haskap (44 mg 100 g^{-1} wet berries), kiwifruit (69 mg 100 g^{-1} wet berries) and lemon (100 mg 100 g^{-1} wet berries) possesses high contents of vitamin C (Standard Tables of Food Composition in Japan 2010). The content of vitamin C in fully ripened silver vine berries was remarkably higher than those in other fruits.

Sensory evaluation: Sensory tests were performed to decide the best suitability of dilution proportion of the beverage made from fully ripened silver vine berries. The sensory scores for colour, taste and aroma, body and overall acceptability on 7 point Hedonic scale among different dilution ranged from 6.0 to 6.7, 3.9 to 6.7, 4.0 to 6.6 and 4.6 to 6.8, respectively, with maximum scores for sensory characteristics in beverage-hot water in 20:80 ratio and minimum in 5:95 (Table 2). Increase in the level of beverage beyond 20% resulted in decreased sensory score which might be due to increase sugar content: the beverage was too sweeter to drink. Beverages in the proportion of 5:95 and 10:90 ratios (beverage-hot water) had a weak sour acidic taste (Table 2). So, colour, taste and aroma (Brix:acid ratio), body and overall acceptability of the beverage were observed highly acceptable when the beverage-hot water were blended in the ratio of 20:80. For comparison, sensory tests were also performed using Yuzu-cha has become widely drink in our country (Biken Co. Ltd., Oita, Japan): beverage was prepared in Yuzu-cha(beverage)-hot water in 13:87 ratio. As a result, similar evaluation was obtained in the beverage made from fully ripened silver vine berries in comparison with the Yuzu-cha (Table 2). It suggested that the beverage made from fully ripened silver vine in the ratio of 20:80 was observed highly acceptable.

Table 1: Chemical parameter of the beverage made from fully ripened silver vine berries

Parameter	Values
Specific gravity	1.291±0.05
Brix % at 20°C	50.8±0.27
pH at 20°C	5.32±0.02
Colour parameter	
L*	76.85±0.54
a*	2.59±0.06
b*	41.07±0.29
Total phenols	283.5±2.76 (μg mL^{-1})
Total vitamin C	185.3±1.83 (μg mL^{-1})

Table 2: Effect of the dilution rate of the beverage made from fully ripened silver vine berries on sensory quality

Beverage:hot water	Colour	Taste and aroma	Body	Overall acceptability
Silver vine				
5:95	6.0±0.05	3.9±0.04	4.0±0.05	4.6±0.05
10:90	6.5±0.08	5.8±0.05	6.1±0.06	6.0±0.05
20:80	6.7±0.08	6.7±0.05	6.6±0.05	6.8±0.04
30:70	6.1±0.06	5.1±0.04	5.5±0.05	5.3±0.04
Yuzu				
13:87	6.5±0.09	6.6±0.06	6.7±0.07	6.8±0.03

Table 3: Antioxidative activities of beverages made from fully ripened silver vine berries

	Absorbance (500 nm)			
	Time (min)			
Sample	0	50	100	200
A	0.000	0.041±0.004	0.120±0.006	0.257±0.012
B	0.000	0.030±0.002	0.067±0.005	0.143±0.006
C	0.000	0.021±0.001	0.048±0.003	0.089±0.009
D	0.000	0.015±0.001	0.032±0.002	0.063±0.005
E	0.000	0.022±0.001	0.135±0.006	0.469±0.027
F	0.000	0.016±0.001	0.032±0.003	0.090±0.008
G	0.000	0.006	0.025±0.001	0.028±0.002
CN	0.000	0.379±0.008	0.715±0.025	1.406±0.041

A: Beverage containing the beverage-hot water in 5:95 ratio, B: Beverage containing the beverage-hot water in 10:90 ratio, C: Beverage containing the beverage-hot water in 20:80 ratio, D: Beverage containing the beverage-hot water in 30:70 ratio, E: 1 mM ascorbic acid, F: 5 mM ascorbic acid, G: 1 mM α-tocopherol, CN: Control

Antioxidative activity: The antioxidative activity of the beverage made from fully ripened silver vine berries was investigated to evaluate the inhibition effects at the initiation stage of linoleic acid peroxidation. Activity of each beverage increased with increasing the concentration of the beverage, although the activity gradually decreased with the passage of time till 200 min (Table 3). The autoxidation of linoleic acid for beverage containing the beverage-hot water in 5:95 ratio was fairly inhibited. The effect for the beverage in the proportion of 10:90 ratio was moderate, which was much higher than that of 1 mM ascorbic acid and was lower than that of 5 mM ascorbic acid. On the other hand, the beverage in the proportion of 20:80 ratio possessed extremely high

Table 4: Superoxide anion radical, hydroxyl radical and DPPH radical scavenging activities of beverages made from fully ripened silver vine berries

	Scavenging activity (%)		
Sample	Superoxide anion radical	Hydroxyl radical	DPPH radical
A	20.1±0.41	15.9±0.23	39.0±2.94
B	52.6±4.15	33.4±2.15	48.2±3.69
C	97.8±3.64	50.2±4.01	67.7±4.72
D	>100	64.7±4.37	86.5±5.58
E	14.7±0.20	13.2±0.21	3.1±0.04*
F	89.9±5.31	17.6±0.71	34.1±2.01**
G	52.6±4.18	67.6±4.34	87.6±2.75
CN	0.0	0.0	0.0

See sample nomenclature in Table 3, *0.1 mM ascorbic acid, **1.0 mM ascorbic acid

activity, which was similar to that of 5 mM ascorbic acid. Moreover, the activity for the beverage in the proportion of 30:70 ratio was strongly high, which did not amount to that of 1 mM α-tocopherol (Table 3). It was suggested that high antioxidative activity of the beverage made from fully ripened silver vine berries contributed to high contents of total phenol components and total vitamin C.

Superoxide anion radical scavenging activity: Superoxide anion radical scavenging activity of the beverage made from fully ripened silver vine berries was measured using xanthine/xanthine oxidase system. Only the beverage containing the beverage-hot water in 5:95 ratio showed the activity about 20%, which had higher activity than 1 mM ascorbic acid (Table 4). The scavenging effect for the beverage in the proportion of 20:80 ratio was to be about 98%, which was significantly higher than that of 5 mM ascorbic acid. The beverage in the proportion of 30:70 ratio completely scavenged the radical (Table 4). The activity tended to increase with an increasing degree of the concentration of the beverage. It is known that superoxide anion radical is effectively scavenged by vitamin C. It was suggested that remarkably high scavenging activity in lower concentration of the beverage was due to high contents of vitamin C contained in the beverage. The concentration of the IC_{50} value against superoxide anion radical activity was calculated to about 10.2% as the beverage made from fully ripened silver vine berries.

Hydroxyl radical scavenging activity: Hydroxyl radical scavenging activity of the beverage made from fully ripened silver vine berries was determined using the Fenton reaction system. The activity for the beverage containing the beverage-hot water in 5:95 ratio was about 16%, which was much higher than that of 1 mM ascorbic acid and was slightly lower than that of 5 mM ascorbic acid (Table 4). The beverage in the proportion of 20:80 ratio scavenged this radical about 50%. The beverage in the proportion of 30:70 ratio showed strongly scavenging activity about 65%, although the activity did not merely amount to that of 1 mM α-tocopherol. (Table 4). Hydroxyl radical efficiently scavenges by α-tocopherol. This result indicates that the beverage made from fully ripened silver vine berries is one of health beverage with high scavenging activity against hydroxyl radical. The concentration of the IC_{50} value against hydroxyl radical activity was calculated to about 21.1% as the beverage made from fully ripened silver vine berries.

DPPH radical scavenging activity: DPPH radical scavenging activity of the beverage made from fully ripened silver vine berries was measured. The activity tended to increase with an increasing degree of the concentration of the beverage. The beverage containing the beverage-hot water in 5:95 ratio scavenged about 39%, which was much higher activity than 1 mM ascorbic acid (Table 4). The activity for the beverage in the proportion of 20:80 ratio was found to be about 68% and moreover it in the proportion of 30:70 ratio was strong, which was similar to that of 1 mM α-tocopherol (Table 4). It is known that DPPH radical scavenging activity is correlated with the contents of total phenols in sample species. It was suggested that the highest DPPH radical scavenging activity of the beverage made from fully ripened silver vine berries attributed to high contents of total phenolic components. The concentration of the IC_{50} value against DPPH radical activity was calculated to about 13.7% as the beverage made from fully ripened silver vine berries.

ACE inhibitory activity: ACE inhibitory activity of the beverage made from fully ripened silver vine berries was investigated. As a result, the beverage inhibited ACE activity in a concentration-dependent manner; the activity increased with an linear increasing degree of the concentration of the beverage (Table 5). The beverage containing the beverage-hot water in 20:80 ratio inhibited the activity about 55% and the activity was completely inhibited by the beverage in the proportion of 30:70 ratio (Table 5). On the other hand, the concentration of the IC_{50} value against ACE activity was calculated to about 16.8% as the beverage made from fully ripened silver vine berries.

DISCUSSION

In the present study, it found that the contents of total phenols and total vitamin C were remarkably high in the beverage made from fully ripened silver vine berries. So the correlation between the content of vitamin C in the

Table 5: ACE inhibitory activities of beverages made from fully ripened silver vine berries

Sample species	Activity (%)
A	10.9±0.51
B	23.4±0.73
C	54.7±0.94
D	98.9±1.08

See sample nomenclature in Table 3

Table 6: Correlation between the contents of total vitamin C and the scavenging activity and ACE inhibitory activity of the beverage made from fully ripened silver vine berries

	Equation	r
Superoxide anion radical	y = 2.6906x-1.0000	0.994
Hydroxyl radical	y = 1.1388x+5.4078	0.963
DPPH radical	y = 1.3843x+14.933	0.897
ACE inhibition	y = 1.7742x-5.1586	0.983

beverage and scavenging activities against these radicals and ACE inhibitory activity were investigated. High correlation was demonstrated between the content of total vitamin C in the beverage and scavenging activities against superoxide anion radicals and hydroxyl radicals and ACE inhibitory activity, with R^2 = 0.994, 0.963 and 0.983, respectively (Table 6). The correlation coefficient for scavenging activity against DPPH radicals was moderate, R^2 = 0.897. These tendencies were also recognized in between the content of total phenols in the beverage and scavenging activities against these radicals and ACE inhibitory activity.

Recent researches have highlighted the importance of the antioxidant constituents of plant foods such as fruits and vegetables (Ali *et al*., 2008; Bakkali *et al*., 2008; Chandra and Ramalingam, 2011; Jang *et al*., 2011; Jeong *et al*., 2004; Jung *et al*., 2005; Singh *et al*., 2008). Particularly, high consumption of fruits has proven to be associated with lower incidence and mortality rate of various degenerative diseases such as cancer, cardiovascular disease and immune dysfunction by several human cohort and case-control studies (Gandini *et al*., 2000; Gaziano and Hennikens, 1996; Ziegler, 1991). The human body has a lot of defense systems to the harmful effects of free radicals and other reactive oxygen species. Normally, there is a balance between oxidant and antioxidant compounds in an organism. There are internal and external defense systems of antioxidants against the reactive oxygen radicals produced depending on internal and external factors. Any insufficiency in the antioxidant defense system changes the balance in favor of oxidants. High levels of antioxidants have an effective role of preventing atherosclerosis, cancer, early aging and lipid peroxidation (Fukai *et al*., 2009; George and Redpath, 2008; Jang *et al*., 2010; Jo *et al*., 2010; Lee *et al*., 2008; Ou *et al*., 2002).

The antioxidant vitamin content of plant foods has attributed them the protective role (Davey *et al*., 2000). Recent interest in food phenolics, however, has increased greatly, because of their antioxidant and free radical scavenging activities (Chen *et al*., 2008; Negro *et al*., 2003; Vinson *et al*., 1998). All of the most commonly sold fruit juices contain phenolic components showing a wide range of antioxidant activities *in vitro* (Paganga *et al*., 1999; Rice-Evans *et al*., 1996; Sun *et al*., 2002; Wang *et al*., 1996). Individual antioxidant compounds do not act alone (Strazzulo *et al*., 2007). They act in combination with other antioxidants, as interactions among them can affect total antioxidant capacity, producing synergistic or antagonistic effects (Niki and Noguchi, 2000). Because plant foods contain many different classes and types of antioxidants, knowledge of their total antioxidant capacity, which is the cumulative capacity of food components to scavenge free radicals, would be useful for epidemiologic purposes (Pellegrini *et al*., 2003).

Our present research indicated that a large amount of vitamin C and phenols possessed in the beverage made from fully ripened silver vine berries. The beverage prepared by dilution of the beverage exhibited the highest antioxidative activity, including the ability to inhibit the autoxidation of linoleic acid and the scavenging effects on superoxide anion radicals, hydroxyl radicals and DPPH radicals. In other words, the beverage made from fully ripened silver vine berries could protect oxidation of lipids and capture these radicals in a concentration-dependent manner. The beverage also showed the strongest ACE inhibitory activity. High scavenging and inhibition activities correlated with the high contents of total phenolic components and vitamin C in the beverage made from fully ripened silver vine berries. Fully ripened silver vine berries, as it has been mentioned, constitute an interesting plant source of phytochemicals and natural antioxidants, which increases the benefits to human health, is a promising field. The development of a low cost, an enhanced value-added and a health-promoting processed foodstuffs using low utilization of materials such as the beverage may be benefit in the food and medical industries.

CONCLUSION

In summary, we have demonstrated highly health-promoting potentials of beverage made from fully ripened silver vine berries using different approaches. Beverage possessed strong antioxidant capacity, scavenging abilities against reactive oxygen species such as superoxide anion radicals, hydroxyl radicals and DPPH radicals and antihypertensive activity; it seems to be related to the abilities to a great amount of vitamin C. It

may be expected the prevention of life-style related diseases as cancer and hypertension by continued drinking of the beverage.

REFERENCES

Ali, S.S., N. Kasoju, A. Luthra, A. Singh, H. Sharanabasava, A. Sahu and U. Bora, 2008. Indian medicinal herbs as sources of antioxidants. Food Res. Int., 41: 1-15.

Amerine, M.A., R.M. Pangborn and E.B. Roessler, 1965. Principles of Sensory Evaluation of Food. 2nd Edn., Academic Press, New York, USA., Pages: 602.

Bakkali, F., S. Averbeck, D. Averbeck and M. Idaomar, 2008. Biological effects of essential oils: A review. Food Chem. Toxicol., 46: 446-475.

Balentine, D.A., S.A. Wiseman and L.C. Bouwens, 1997. The chemistry of tea flavonoids. Crit. Rev. Food Sci. Nutr., 37: 693-704.

Chandra, H.M. and S. Ramalingam, 2011. Antioxidant potentials of skin, pulp, and seed fractions of commercially important tomato cultivars. Food Sci. Biotechnol., 20: 15-21.

Chen, X.N., J.F. Fan, X. Yue, X.R. Wu and L.T. Li, 2008. Radical scavenging activity and phenolic compounds in persimmon (*Diospyros kaki* L. cv. Mopan). J. Food Sci., 73: C24-C28.

Davey, M.W., M. Van Montagu, D. Inze, M. Sanmartin and A. Kanellis *et al*., 2000. Plant L-ascorbic acid: Chemistry, function, metabolism, bioavailability and effects of processing. J. Sci. Food Agric., 80: 825-860.

Fukai, S., S. Tanimoto, A. Maeda, H. Fukuda, Y. Okada and M. Nomura, 2009. Pharmacological activity of compounds extracted from persimmon peel (*Diospyros kaki* Thunb.). J. Oleo Sci., 58: 213-219.

Gandini, S., H. Merzenich, C. Robertson and P. Boyle, 2000. Meta-analysis of studies on breast cancer risk and diet: The role of fruit and vegetable consumption and the intake of associated micronutrients. Eur. J. Cancer, 36: 636-646.

Gaziano, J.M. and C.H. Hennikens, 1996. Update on dietary antioxidants and cancer. Path. Biol., 44: 42-45.

George, A.P. and S. Redpath, 2008. Health and medicinal benefits of persimmon fruit: A review. Adv. Hort. Sci., 22: 244-249.

Jang, I.C., E.K. Jo, M.S. Bae, H.J. Lee, K.I. Jeon, E. Park, H.G. Yuk, G.H. Ahn and S.C. Lee, 2010. Antioxidant and antigenotoxic activities of different parts of persimmon (*Diospyros kaki* cv. Fuyu) fruit. J. Med. Plants Res., 4: 155-160.

Jang, I.C., W.G. Oh, G.H. Ahn, J.H. Lee and S.C. Lee, 2011. Antioxidant activity of 4 cultivars of persimmon fruit. Food Sci. Biotechnol., 20: 71-77.

Jeong, S.M., S.Y. Kim, D.R. Kim, S.C. Jo and K.C. Nam *et al*., 2004. Effect of heat treatment on antioxidant activity of citrus peels. J. Agric. Food Chem., 52: 3389-3393.

Jo, Y.H., J.W. Park, J.M. Lee, H.R. Park and G.H. Ahn *et al*., 2010. Antioxidant and anticancer activities of methanol extracts prepared from different parts of Jangseong Daebong persimmon (*Diospyros kaki* cv. Hachiya). J. Korean Soc. Food Sci. Nutr., 39: 500-505.

Jung, S.T., Y.S. Park, Z. Zachwieja, M. Folta and H. Barton *et al*., 2005. Some essential phytochemicals and the antioxidant potential in fresh and dried persimmon. Int. J. Food Sci. Nutr., 56: 105-113.

Katiyar, S.K., R. Agarwal, G.S. Wood and H. Mukhtar, 1992. Inhibition of 12-*O*-tetradecanoylphorbolacetate-caused tumor promotion in 7,12-dimethylbenz[α]anthracene-initiated SEN-CAR mouse skin by a polyphenolic fraction isolated from green tea. Cancer Res., 52: 6890-6897.

Lee, Y.A., E.J. Cho and T. Yokozawa, 2008. Protective effect of persimmon (*Diospyros kaki*) peel proanthocyanidin against oxidative damage under H_2O_2-induced cellular senescence. Biol. Pharm. Bull., 31: 1265-1269.

Matsuzaki, T. and Y. Hara, 1985. Antioxidative activity of tea leaf catechins. Nippon Nogei Kagaku Kaishi, 59: 129-134..

Nagai, T. and T. Nagashima, 2006. Functional properties of dioscorin, a soluble viscous protein from Japanese yam (*Dioscorea opposita* Thunb.) tuber mucilage *tororo*. Z. Naturforsch., 61: 792-798.

Negro, C., L. Tommasi and A. Miceli, 2003. Phenolic compounds and antioxidant activity from red grape marc extracts. Bioresource Technol., 87: 41-44.

Niki, E. and N. Noguchi, 2000. Evaluation of antioxidant capacity. What capacity is being measured by which method? IUBMB Life, 50: 323-329.

Ou, B., D. Huang, M. Hampsch-Woodill, J.A. Flanagan and E.K. Deemer, 2002. Analysis of antioxidant activities of common vegetables employing oxygen radical absorbance capacity (ORAC) and ferric reducing antioxidant power (FRAP) assays: A comparative study. J. Agric. Food Chem., 50: 3122-3128.

Paganga, G., M. Miller and C.A. Rice, 1999. The polyphenolic content of fruit and vegetables and their antioxidant activities. What does a serving constitute? Free Radical Res., 30: 153-162.

Pellegrini, N., M. Serafini, B. Colombi, D. Del Rio and S. Salvatore *et al*., 2003. Total antioxidant capacity of plant foods, beverages and oils consumed in Italy assessed by three different *in vitro* assays. J. Nutr., 133: 2812-2819.

Rice-Evans, C.A., N.J. Miller and G. Paganga, 1996. Structure-antioxidant activity relationships of flavonoids and phenolic acids. Free Radic. Biol. Med., 20: 933-956.

Singh, G., I.P. Kapoor, P. Singh, C.S. de Heluani, M.P. de Lampasona and C.A. Catalan, 2008. Chemistry, antioxidant and antimicrobial investigations on essential oil and oleoresins of *Zingiber officinale*. Food Chem. Toxicol., 46: 3295-3302.

Slinkard, K. and V.L. Singleton, 1977. Total phenol analysis: Automation and comparison with manual methods. Am. J. Enol. Viticult., 28: 49-55.

Standard Tables of Food composition in Japan, 2012. Kagawa, Y. (Ed.). Kagawa Nutrition University Publishing Division, Tokyo, ISBN 978-4-7895-1012-7.

Strazzulo, G., A. De Giulio, G. Tommonaro, C. La Pastina and A. Poli *et al*., 2007. Antioxidant activity and lycopene and β-carotene contents in different cultivars of tomato (*Lycopersicon esculentum*). Int. J. Food Prop., 10: 321-329.

Sun, J., Y.F. Chu, X. Wu and R.H. Liu, 2002. Antioxidant and antiproliferative activities of common fruits. J. Agric. Food Chem., 50: 7449-7454.

Tepper, B.J., Y.S. Choi and R.M. Nayga, 1997. Understanding food choice in adult men: Influence of nutrition knowledge, food beliefs and dietary restraint. Food Qual. Prefer., 8: 307-317.

The Vitamin Society of Japan, 1990. Vitamin Handbook. Kagakudojin, Kyoto, Japan, ISBN-13: 978-4759801903, pp: 139-140.

Vinson, J.A., Y. Hao, X. Su and L. Zubik, 1998. Phenol antioxidant quantity and quality in foods: Vegetables. J. Agric. Food Chem., 46: 3630-3634.

Wang, H., G. Cao and R.L. Prior, 1996. Total antioxidant capacity of fruits. J. Agric. Food Chem., 44: 701-705.

Yen, G.C. and H.Y. Chen, 1994. Comparison of the antimutagenic effect of various tea extracts(green, oolong, pouchong and black tea). J. Food Prot., 57: 54-58.

Ziegler, R.G., 1991. Vegetables, fruits and carotenoids and the risk of cancer. Am. J. Clin. Nutr., 53: 251S-259S.