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Antioxidant Activities and Total Phenolic Content of Multi-colored Fruits and Vegetables in Thailand

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Abstract

Fruits and vegetables are valuable sources of natural phenolic antioxidants which are known to have beneficial health promoting properties. The main objectives of this study were to compare the antioxidant activities and total phenolic and flavonoid contents of ten ethanolic edible plant extracts (Five species of fruits and vegetables) with varieties of colors. The result showed that purple color of plants, including ethanolic extracts of Brassica oleracea Linn. (40.7 ± 0.56%) and Vigna sesquipedalis (4.52 ± 0.01%) significantly showed the highest TPC and TFC compared with the same species and other species with different colors ($p<0.01$). Measurement of antioxidant capacity, yellow Capsicum annuum Linn. (58.72±0.52%) and purple Solanum melongena Linn. extract (22.44 ± 1.20%) significantly showed the maximum antioxidant activities by DPPH radical scavenging activity assay and ferric ion reducing antioxidant power (FRAP) assay, respectively ($p<0.01$). Base on shades of color pigment extracts, green and red pigment had more potential antioxidant activities than other colors. The purple and yellow pigments showed the maximum total phenolic contents by Folin-Ciocalteu reagent. These results concluded that purple color of plants; Brassica oleracea Linn. and Vigna sesquipedalis in this study had the potential to be a suitable source of cheap phenolics and flavonoids as antioxidant compounds.

Keywords : *Edible plant extracts,Antioxidant activity, Total phenolic and flavonoid contents, Fruits and vegetables*

1. Introduction

Antioxidant compounds such as phenolic acids, polyphenols and flavonoids can scavenge free radicals and result in inhibition of oxidative mechanisms which are responsible for many disorders and diseases inhumans (1) such as infections, diabetes, arthritis, cardiovascular diseases, cancer and Alzheimer's diseases (2, 3). Potential sources of antioxidant compounds have been searched in several types of plant materials (4, 5) such as vegetables, fruits, leaves, roots and crude plant extracts (6, 7, 8). Fruits and vegetables are edible plants

which are known as source of beneficial nutrients such as minerals, polyphenols (9) and vitamins which provide health benefits in addition to their nutritional value. They have long been recognized as a rich source of natural antioxidant compounds or phytochemical substances.Fruits and vegetables that are blue, purple, red, orange, yellow and green often contain higher nutrients and antioxidants (10, 11, 12). Different colors indicated different nutrient profiles and potential antioxidant activities (13).On the color wheel, the purple-blue-red-orange spectrum is home to the most antioxidant-rich fruits (14).

Plant polyphenols are known to have multifunctionalproperties such as reducing agents, hydrogen donating antioxidants and singlet oxygen quenchers. Flavonoids and their derivatives are the largest and mostimportant group of polyphenols. Among the variety of phenolic compounds, phenolicacids have attracted considerable interest in the pastfew years due to their many potential health benefits. As phenolic compound, phenolic acids are powerful antioxidantsand have been reported to demonstrate antibacterial, antiviral, anti-carcinogenic, anti-inflammatory and vasodilatory actions (15, 16). Though many other plant species have been investigated in the search for novel antioxidants but generally there is still demand to find more information concerning the antioxidant potential of plant species as they are safe and also bioactive. Therefore, ten most prominently utilized fruits and vegetables in Thailand were selected for investigation of antioxidant activity.

2. Materials and Method

2.1 Plant materials

A total of 10 edible plant materials (five species of fruits and vegetables) in different shades of color were selected from local market and Big C Supermarket, Bangkok province, in the central region of Thailand. All of them (Table 1) are commonly consumed in Thailand.

Table 1. Description of the 10 studied plant material samples

Scientific name	Family	Common name	Color	Part used
Vegtables				
Capsicum annuum Linn.	Solanaceae	Bell pepper	Yellow, Red and Green	Fruits
Solanum melongena Linn.	Solanaceae	Egg plant	Green and Purple	Fruits
Brassica oleracea Linn.	Brassicaceae	Cabbage	Green and Purple	Leaves
Lycopersicon esculentum	Solanaceae	Cherry tomato	Red and Yellow	Fruits
Vigna sesquipedalis	Fabaceae	Yardlong bean	Green and Purple	Seeds
Fruits				
Malus domestica	Rosaceae	Apple	Red and Green	Fruits
Citrullus lanatus (Thunb.)	Cucurbitaceae	Water melon	Red and Yellow	Fruits
Hylocereus polyrhizus	Cactaceae	Dragon Fruit	Red and white	Fruits
Vitis vinifera Linn.	Vitaceae	Grape	Red and Green	Fruits
Citrus maxima	Rutaceae	Pomelo	Yellow and Pink	Fruits

2.2 Sample preparation and extraction

All edible plant materials were thoroughly cleaned and soaked with 70% ethanol for 15 min. The different samples were prepared and soaked in 95% ethanol in a ratio of 1:2 for 1-2 day separately. Then, the liquid extract was filtered and centrifuged at 2000 rpm for 20 min at room temperature to obtain a clear supernatant and wasused for analyzing the total phenolic and flavonoid content, reducing power and their free radical scavenging capacity. The ethanolic extracts were stored at -20◦C under dark condition until further analysis. The final weight of the crude extracts were weighted and calculated for the percentage yield.

2.3 Estimation of total phenolics content

The amount of total phenolic content (TPC) of crude ethanolicextracts was determined according to Folin-Ciocalteuprocedure (17, 18). Briefly,100 µl of the tested samples were introduced into test tubes; 750 µl of fresh Folin -Ciocalteu reagent (diluted in distilled water (1:10)) and 750 µl of 6% (w/v) sodium carbonate (Na_2CO_3) was added and allowed to completely react for 90 min at room temperature in the dark condition. Absorbance at 725 nm was measured on

a spectrophotometer. The total phenolic content was expressed as gallic acid equivalents in milligram per gram of fresh weight (mgGAE/100gFW) using the linear equation based on standard calibration curve of the gallic acid (0.02 - 0.1 mg/ml).

2.4 Estimation of total flavonoids content

Total flavonoids content (TFC) in plant extracts were estimated by aluminium chloride colorimetric assay (19).Two hundred microliters of sampleextracts were then added in 2.3 ml of 30% of methanol. The mixture was added with 100 µl of 0.5 M $NaNO_2$ and 100 µl 0.3 M $AlCl_3$, respectively. Next, the sample solution was thoroughly mixed with vortex and kept in the dark for 5 min. And then, the absorbance at 506 nm was measured using by spectrophotometer. A yellow color indicated the presence of flavonoids. The total flavonoid content was expressed asrutin equivalents in milligram per gram of fresh weight(mg RE/g FW) using the linear equation based on calibration curve of rutin (0.01-0.05 mg/ml)

2.5 DPPH free radical scavenging assay

The antioxidant activities of plant extracts were evaluated through free radical scavenging effect on 1,1-diphenyl-2-picrylhydrazyl (DPPH) radical. This assay was determined by the method of Akowuah *et al*., (2005) (20). DPPH solution was prepared freshly at a concentration of 0.1 mM in methanol. An aliquot of 100 µl of each extract solution was mixed with 900 µl of methanolic DPPH solution. The mixture was thoroughly mixed and left to stand for 15 min in the dark and absorbance was recorded at 517 nm using spectrophotometer. Ascorbic acid (0.01-0.05 mg/ml) was used as standard and was prepared using the similar procedure.

2.6 Determination of ferric reducing/ antioxidant power assay (FRAP)

The total reducing capacity was determined by using FRAP assay which was performed according to the method of Benzie and Strain (1996) (21) with some modification. The FRAP reagent was initially prepared, consisting of 300mM acetate buffer (pH 5.6), 10mM 2,4, 6-Tripyridyl-s-triazine (TPTZ) solution in 40 mM HCl and 20 mM $FeCl_3.6H_2O$ solution in a ratio of 10:1:1 (v/v/v). An amount of 300 µl plant extracts was mixed with 2.7 ml of the FRAP reagent in test tubes by vortex. the absorbance was measured at 596 nm by using spectrophotometerafter incubation for 30 min. The results were expressed as ascorbic acid equivalents in milligram per gram fresh weight (mg AAE/g FW) based on calibration curve of ascorbic acid (0.01-0.05 mg/ml).

2.7 Statistical Analysis

All data were expressed as means ± standard deviation of (n=6) measurements. Statistical analyses (ANOVA) were performed with the statistical program MS Excel (Microsoft Office 2010 Professional). P-values less than 0.05 were considered significant ($P<0.05$).

3. Results and Discussion

3.1 Total phenolics content (TPC)

Typical phenolics that possess antioxidant activity are known to be mainly phenolic acids and flavonoids. Phenolic acids are a major class of phenolic

compounds, widely occurring in the plant kingdom especially in fruits and vegetables (9). Natural antioxidants are responsible for inhibiting or preventing the deleterious consequences of oxidative stress (18). The amount of total phenolics compounds of different plant samples was measured by Folin-Ciocalteu method, varied widely in edible plant materials and ranged from 0.84±0.05 (green Brassica oleracea Linn.) to 40.70±0.56 (purple Brassica oleracea Linn.) mg GAE/100g FW (Table 2).

The maximum content of total phenolics was found in purple Brassica oleracea Linn. followed by purple Solanum melongena Linn., yellow Lycopersicon esculentum, green Solanum melongena Linn. and red Lycopersicon esculentum, respectively. Among the ethanolic vegetable extracts, the highest level of phenolics was recorded in purple Brassica oleracea Linn., whereas the lowest was in green Brassica oleracea Linn., which was consistent with the data reported by Bunga et al., (2014) (22).

Among the ethanolic fruit extracts,the highest level of phenolics was found in yellow Citrus maxima while the lowest was in red Citrullus lanatus (Thunb.) ($P>0.05$). Whenconsidering shades of color, the amount of total phenolics in these plant materials are in descending order of purple > yellow > green > red > white. The total phenolic contents of the vegetable ethanolic extracts had significantly higher than these of the fruit ethanolic extracts ($P < 0.05$).

3.2 Total flavonoids content (TFC)

Flavonoids is one of the most diverse and widespread group of natural compounds which are probably the most important natural phenols (23). Many researchers attempt to find the novel natural source of bioactive compounds such as antioxidant substances (24).Total flavonoid contents (TFC) in various colors of plant materialsare given in Table 2. TFC were determined by using spectrophotometric method with aluminum chloride and expressed in terms of rutin equivalent (RE). The total flavonoids content in this study was presented between 0.12±0.05 (yellow Citrus maxima) and 4.52±0.01 (purple Vignas esquipedalis) mg RE/100gFW. But the content of flavonoids in ethanolic Citrullus lanatus (Thunb.) extracts was not found. The total flavonoids content was the highest in purple Vignas esquipedalis followed by purple Brassica oleracea Linn., red Lycopersicon esculentum, green Malus domestica and yellow Lycopersicon esculentum, respectively. Among the ethanolic vegetable extracts, the highest level of TFC was found in purple Brassica oleracea Linn. while the lowest was in green Capsicum annuum Linn. Among the ethanolic fruit extracts, the highest level of phenolics was found in purple Vignas esquipedalis while the lowest was in Citrullus lanatus (Thunb.). When considering shades of color, the amount of total phenolics in these plant materials are in descending order of purple > red > green > yellow > white.

Table 2. The yield, total phenolic and flavonoid content and antioxidant activities of edible plants

Plants	Color	%Extract yield (w/w)	TPC (mg GAE/100g FW)	TFC (mg RE/100g FW)	Antioxidant activities	
					DPPH assay (mg AAE/100g FW)	FRAP assay (mg AAE/100g FW)
***Capsicum annuum* Linn.**	Red	6.65±0.12^{G}	13.37±0.67^{F}	0.42±0.05^{J}	54.72±8.06^{b}	17.36±1.67^{e}
Lycopersicon esculentum		6.79±0.13^{G}	18.42±0.14^{D}	1.92±0.04^{C}	21.68±0.41^{c}	15.12±0.89^{f}
Malus domestica		15.88±0.02^{C}	3.58±0.29^{K}	1.26±0.06^{G}	2.70±0.55^{h}	1.50±0.1^{k}
***Citrullus lanatus* (Thunb.)**		9.19±0.22^{E}	0.94±0.05^{O}	ND	0.35±0.06^{m}	0.06±0.02^{o}
Hylocereuspolyrhizus		17.75±0.08^{B}	1.63±0.25^{M}	0.39±0.05^{J}	0.94±0.18^{k}	0.86±0.01^{m}
***Vitis vinifera* Linn.**		17.75±0.08^{B}	1.63±0.25^{M}	0.39±0.05^{J}	0.94±0.18^{k}	0.86±0.01^{m}
Citrus maxima		9.7±0.20^{DE}	4.33±0.17^{IJ}	0.13±0.01^{N}	2.66±0.36^{h}	1.54±0.02^{jk}
***Capsicum annuum* Linn.**	Green	6.66±0.12^{G}	9.29±0.32^{H}	0.27±0.11^{L}	58.72±4.52^{a}	9.34±0.51^{h}
***Solanum melongena* Linn.**		5.68±0.05^{GH}	18.78±0.91^{D}	0.95±0.03^{H}	8.61±0.76^{e}	20.8±1.36^{c}
***Brassica oleracea* Linn.**		4.9±0.06^{I}	0.84±0.05	0.30±0.02^{K}	2.02±0.34^{i}	1.74±0.07^{j}
Vigna sesquipedalis		9.02±0.02^{E}	4.90±0.18^{I}	1.77±0.11^{E}	3.84±0.62^{g}	12.66±1.74^{g}
Malus domestica		20.18±0.02^{A}	4.02±0.01^{J}	1.87±1.23^{D}	1.78±0.24^{i}	1.25±0.08^{l}
***Vitis vinifera* Linn.**		14.57±0.19^{C}	1.94±0.33^{L}	0.50±0.07^{I}	1.18±0.24^{j}	1.02±0.07^{l}
***Capsicum annuum* Linn.**	Yellow	5.64±0.18^{H}	16.59±0.43^{E}	0.31±0.08^{K}	17.2±2.19^{d}	20.14±2.95^{c}
***Lycopersicon* esculentum**		6.51±0.05^{G}	22.92±0.25^{C}	1.59±0.28^{F}	22.32±0.21^{c}	19.72±0.34^{d}
***Citrullus lanatus* (Thunb.)**		10.43±0.16^{D}	1.10±0.08^{N}	ND	0.37±0.03^{lm}	0.05±0.01^{o}
Citrus maxima		8.75±0.23^{E}	4.95±0.59^{I}	0.12±0.05^{N}	2.26±0.29^{i}	2.12±0.04^{i}
***Solanum melongena* Linn.**	Purple	5.93±0.12^{G}	31.28±1.85^{B}	1.24±0.12^{G}	8.77±0.73^{d}	22.44±1.20^{a}
***Brassica oleracea* Linn.**		7.76±0.04^{F}	40.70±0.56^{A}	2.67±0.12^{B}	6.50±0.47^{f}	21.32±1.10^{b}
Vignas esquipedalis		7.29±0.13^{F}	11.20±0.66^{G}	4.52±0.01^{A}	6.26±0.73^{f}	19.84±1.87^{d}
Hylocereus polyrhizus	White	17.87±0.87^{B}	0.99±0.08^{N}	0.16±0.02^{M}	0.40±0.01^{l}	0.30±0.06^{n}

GAE = Gallic Acid Equivalent; RE = Rutin Equivalent; AAE = Ascorbic acid Equivalent; ND = Not Detected

^{ABCDEFGHIJKLMN} means in the same column with different superscript were significantly different ($P < 0.05$) by one way ANOVA and paired T-test

^{abcdefghijklmno,} means in the same column with different superscript were significantly different ($P < 0.01$) by one way ANOVA and paired T-test

3.3 Antioxidant activities

The antioxidant activities of the ethanolic edible plant extracts were showed significantly different between varieties. It was evidence that the varieties with colored flesh significantly exceed white-flesh varieties (Table 2). DPPH is a stable and free radical. It is commonly used as a substrate to evaluate in vitro antioxidant activity of extracts of fruits, vegetables and medicinal plants compared with other methods. Antioxidants can scavenge the radical by hydrogen donation, which causes a decrease of DPPH absorbance at 517 nm. This method is widely used to evaluate antioxidant activities within a relatively short time when compared with other methods. The result clearly showed that all edible plant extracts had DPPH radical scavenging activity ranging from 0.35±0.06 (red Citrullus lanatus (Thunb.)) to 58.72±0.52 (green Capsicum annuum Linn) mg AAE/100g FW. The ethanolic extracts of green Capsicum annuum Linn. showed the highest of DPPH value and the red Citrullus lanatus (Thunb.) showed its lowest. The DPPH radical scavenging activity of the vegetable ethanolic extracts had significantly higher than that of the fruit ethanolic extracts ($P < 0.05$).When considering shades of color, the total phenolic content in these plant materials decreased in the following order: green > red > yellow > purple > white.

3.4 FRAP

The antioxidant potential of the plant species was ascertained from FRAP assay based on their ability to reduce TPTZ-Fe^{3+} complex to TPTZ-Fe^{2+}. TPTZ-Fe^{2+} is an intensive blue color and can be monitored at 596 nm. Reducing power is associated with antioxidant activity and may serve as a significant reflection of the antioxidant activity (20, 25). In this assay, the yellow color of the test solution changes to various shades of green and blue depending on the reducing power of each compound. Maximum reducing capacity was presented in the purple Solanum melongena Linn. (22.44±1.20AAE/100g FW) (Table 2) whereas low reducing power was found in the yellow Citrullus lanatus (Thunb.) (0.05±0.01AAE/100g FW). The reducing capacity of the vegetable extracts had significantly higher than that of the fruit extracts ($P < 0.05$). Moreover, the total phenolic content in these plant materials decreased in the following order: purple > green > yellow > red > white.

Antioxidant compounds (phenolics and flavonoids) and their antioxidant activity in five different colors (purple, green, yellow, red, and white) of the edible plants were investigated. Among these plant extracts, the purple plants had higher level of the total phenolicand flavonoid contents than the other colors, while the white plants had lower level of the total phenolic and flavonoid contents than the other colors. The varieties with colored flesh significantly exceed traditional white (Table 2). This fact is confirmed by data in Figure 1-2, which compare the groups of varieties with different flesh color. In this study, the colors in the ethanolic extracts of samples were pigments that found in general plants including the expected carotenoids (red and orange), beta-carotene (yellow and orange), anthocyan lycopene (red), anthocyanins (purple), flavonoids (yellow), betalains, and chlorophylls (green). All of them act as

antioxidant compounds. The pigments found in plants play important roles in plant metabolism and visual attraction in nature. They are also important for humans, attracting our attention and providing us with nutrients.

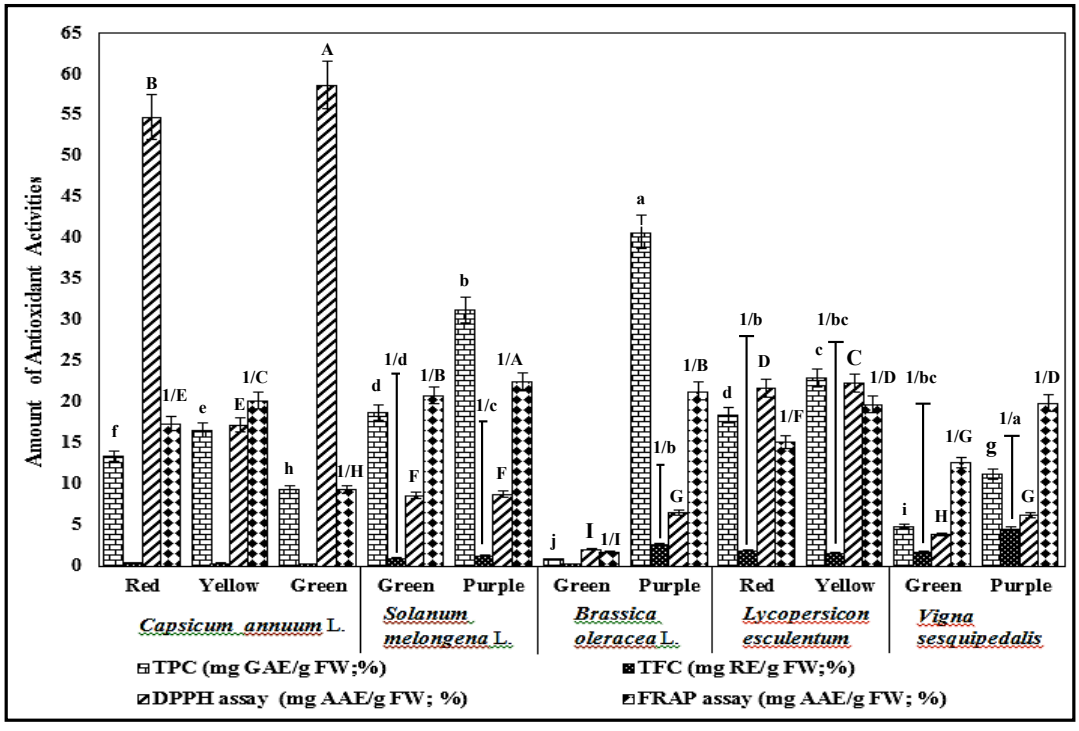

Figure 1. Impact of varieties with different flesh color on the total phenolics and flavonoids content and antioxidant activity of vegetable materials (a-j, 1/a-d: $p<0.05$; one way ANOVA and paired T-test and A-I and 1/A-G: $p<0.01$; one way ANOVA and paired T-test)

4. Conclusion

The antioxidant activities of edible fruits and vegetables were determined. Based on these studies, it can be concluded that the total phenolics and flavonoids contents were dependent on pigments in plant extracts. Purple color of the plants (Brassica oleracea Linn. and Vignas esquipedalis) showed the highest TPC and TFC. Moreover, the antioxidant activity of the ethanolic extract varies with its ability to react with the harmful free radicals. Among all these fruits, green Capsicum annuum Linn. and purple Solanum melongena Linn. showed the highest antioxidant capacity. Therefore, these edible fruits and vegetables could be exploited as antioxidant additives or as nutritional supplements. The providing data can enrich the existing comprehensive data of antioxidant activity of wild fruits and its biological value. In this study, the differences in the total phenolics and flavonoids contents were statistically significant

between the different varieties of species. The frequent consumption of vegetables and fruits in various colorful will be the positive impact on the health.

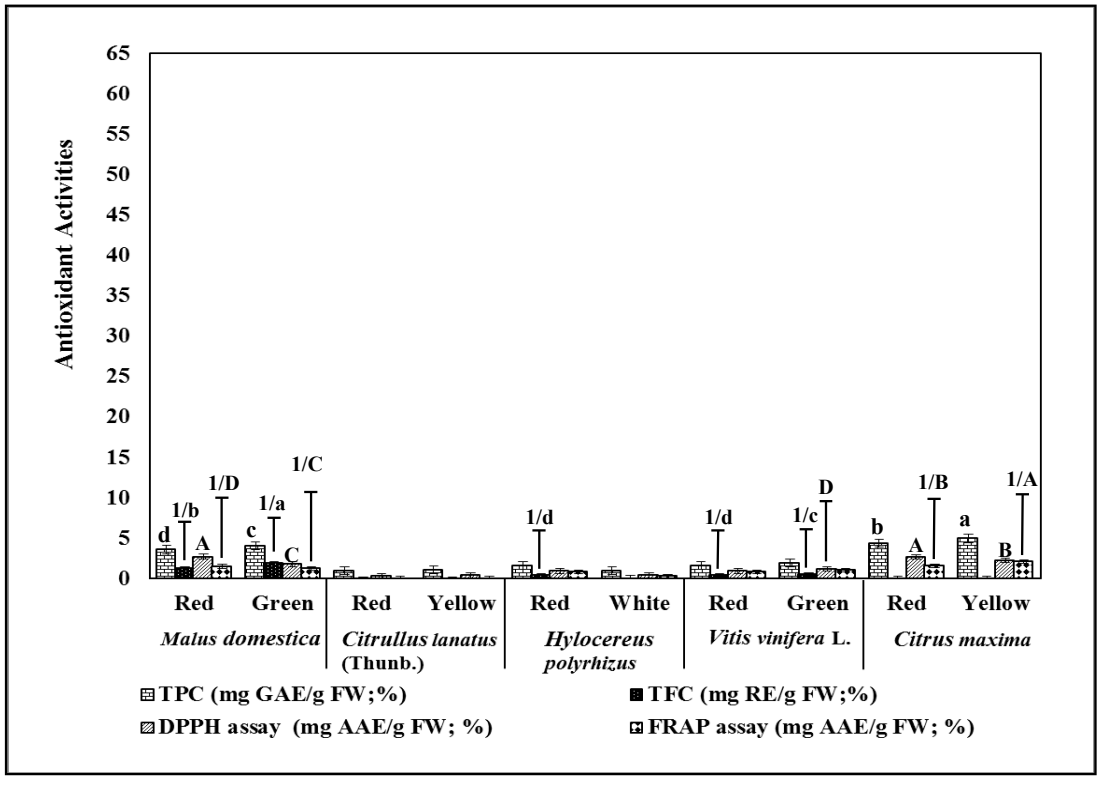

Figure 2. Impact of varieties with different flesh color on the total phenolics and flavonoids content and antioxidant activity of fruit materials (a-d, 1/a-d: $p<0.05$; one way ANOVA and paired T-test and A-D and 1/A-D: $p<0.01$; one way ANOVA and paired T-test)

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6. References

(1) Valko M, Leibfritz D, Moncol J, Cronin MT, Mazur M, Telser J. Free radicals and antioxidants in normal physiological functions and human disease. Int J Biochem Cell Bio. 2007;39(1): 44–84.

(2) Patel VR, Patel PR, Kajal SS. Antioxidant activity of some selected medicinal plants in western region of India. Advan Biol Res.2010;4(1): 23-26.

(3) Jin Dai and Russell J Mumper, Plant phenolics: extraction, analysis and their antioxidant and anticancer properties. Molecules. 2010; 15: 7313-7352

(4) Li F, Bo-Tao X, Xiang-Rong X, Ren-You G, Yuan Z, En-Qin X, et al. Antioxidant capacities and total phenolic contents of 62 fruits. Food Chem., 2011;129(2): 345-350.

(5) Adhikarimayum H, Kshetrimayum G. Total Antioxidant capacity of twenty wild and cultivated fruits. Int J Agric Food Sci. 2012, 2 (4): 146-148.

(6) Karadag A, Ozeelik B, Saner S. Review of methods to determine antioxidant capacities. Food Anal Method. 2009;2(1):41–60.

(7) Krout AA, Mighri H, Krid M, Thabet F, Turki H, El-Jani H, et al. Chemical composition and antioxidant activity of aqueous extracts of some wild medicinal plants in Southern Tunisia. Int J Life Sci Med Sci Res. 2012; 2(1):1-4.

(8) RashidaP, Naveed A. In vitro evaluation of antioxidant activity of phytochemical extracts from different varieties of various plants. Asian J Chem. 2013; 25(18): 10561-10564.

(9) Manach C, Scalbert A,Morand C, Remesy C, Jimenez L. Polyphenols: food sources and bioavailability. Am J Clin Nutr. 2004;79(5),727-747.

(10) Sun T, Xu Z, Wu CT, Janes M, Prinyawiwatkul W, No HK. 2007. Antioxidant activities of different colored sweet bell peppers (Capsicum annuum L.). J Food Sci. 2007;72(2):S98-102.

(11) Nurliyana R, Syed ZI, Mustapha SK, Aisyah MR, Kamarul RK. Antioxidant study of pulps and peels of dragon fruits: a comparative study. Int Food Res J.2010;17: 367-375.

(12) Mia I, Bee LL, Meng TL, Woon-Puay K, Dejian H, Choon NO. Antioxidant activity and profiles of common vegetables in Singapore. Food Chem. 2010;120(4): 993-1003.

(13) Ranajit KS, Shafiqur R, AfandiA. Bioactive compounds in chilli peppers (Capsicum annuum L.) at various ripening (green, yellow and red) stages. Ann Biol Res. 2013;4(8):27-34.

(14) Jae-Hee P, Gyeong-Im J, Jung-Mi K, Eunju P. Antioxidant activity and antiproliferative action of methanol extracts of 4 different colored bell peppers (Capsicum annuum L.).2012;21(2):543-550.

(15) Breinholt V, Desirable versus harmful levels of intake of flavonoids and phenolic acids. In: J Kumpulainen and J.E. Salonen, editor. Natural Antioxidants and Anticarcinogens in Nutrition Health and Disease. The Royal Society of Chem., Cambridge, 1999.p. 190-197.

(16) Duthie GG, Duthie SJ, Kyle JA. Plant polyphenols in cancer and heart disease: Implications as nutritional antioxidants.Nut. Res. Rev.2000;13(1): 79-106.

(17) Materska M, Perucka I. Antioxidant activity of the main phenolic compounds isolated from hot pepper fruit (Capsicum annuum L.). J Agric Food Chem. 2005;53(5): 1750-1756.

(18) Ains worth EA, Gillespie KM. Estimation of total phenolic content and other oxidation substrates in plant tissues using Folin- Ciocalteu reagent. Nat Protoc. 2007;2(4): 875–877.

(19) Liu M, Li XQ, Weber C, Lee CY, Brown J, Liu RH. Antioxidant and antiproliferative activities of raspberries. J Agric Food Chem. 2002;50(10): 2926-2930.

(20) Akowuah GA, Ismail Z, Norhayati I, Sadikun A, The effects of different extraction solvents of varying polarities of polyphenols of Orthosiphon stamineus and evaluation of the free radical-scavenging activity. Food Chem. 2005;93(2): 311-317.

(21) Benzie IFF, Strain JJ. The ferric reducing ability of plasma (FRAP) as a measure of ‘‘antioxidant power’’: the FRAP assay. Anal Biochem. 1996;239(1): 70–76.

(22) Bunga T, Shankar GR, Janapatla S, Ramavath AK. Phytochemical antioxidant properties in green and purple varieties of cabbage. World J Pharma Res. 214;3(10): 1415-1425.

(23) Montoro P, Braca A, Pizza C, De Tommasi N. Structure-antioxidant activity relationships of flavonoids isolated from different plant species. Food Chem 2005, 92: 349–355.

(24) Maria MBA, Paulo HMS, Angela MCA , Giovana MP, Carlos ECM , Geraldo AM, et al. Bioactive compounds and antioxidant activity of fresh exotic fruits from Northeastern Brazil. Food Res Int. 2011;44(7):2155–2159.

(25) Lavanya R, Maheshwari S, Harish G, Raj B, Kamali S, Hemamalani D, et al. In-vitro antioxidant activity of methanolic extract in leaves of Anisomeles malabarica Linn, Res J PharmBiolChem Sci. 2010;1(4): 737-744.