PJN
ISSN 1680-5194

PAKISTAN JOURNAL OF NUTRITION

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

OPEN ACCESS Pakistan Journal of Nutrition

ISSN 1680-5194
DOI: 10.3923/pjn.2018.492.499

Research Article
Antioxidant Activity of *Archidendron pauciflorum*, *Syzygium oleana*, *Mangifera indica*, *Theobroma cacao* and *Cinnamomum burmannii* Young Leaves and Their Application as Jelly Drink Colourants

Tuty Anggraini, Vio Novendra and Novelina

Faculty of Agricultural Technology, Andalas University, 25163 Padang, Indonesia

Abstract

Background and Objectives: Natural dyes have been used in the food industry and pigments from plants are widely used as such dyes. This research aimed to determine the characteristics of natural dye extracts from the young leaves of *Archidendron pauciflorum* (*A. pauciflorum*), *Syzygium oleana* (*S. oleana*), *Mangifera indica* (*M. indica*), *Theobroma cacao* (*T. cacao*) and *Cinnamomum burmannii* (*C. burmannii*) and to examine their application as a colourant in jelly drinks. **Materials and Methods:** The young leaves of *A. pauciflorum*, *S. oleana*, *M. indica*, *T. cacao* and *C. burmannii* were exposed to Folin-Ciocalteu reagents and Diphenyl Pycryl Hydrazyl (DPPH). The method used in this research was exploratory, 5 treatments were performed on young *A. pauciflorum*, *S. oleana*, *M. indica*, *T. cacao* and *C. burmannii* leaf extracts before their subsequent application in a jelly drink. The pH and antioxidant activity were measured, as were the total polyphenol and anthocyanin contents of young leaves of *A. pauciflorum*, *S. oleana*, *M. indica*, *T. cacao* and *C. burmannii* and their subsequent application in jelly drinks. **Results:** The results showed that the antioxidant activity and total polyphenol content of *A. pauciflorum* both in extract and jelly drinks were the highest among the young leaves. Values of the anthocyanin content in young leaves of *A. pauciflorum*, *S. oleana*, *M. indica*, *T. cacao* and *C. burmannii* were 17.90±0.03, 19.34±0.02, 74.39±0.07, 26.84±0.01 and 21.61±0.02 mg L^{-1}, respectively, while the anthocyanin contents of jelly drinks made with *A. pauciflorum*, *S. oleana*, *M. indica*, *T. cacao* and *C. burmannii* jelly drinks were 6.90±0.02, 7.39±0.03, 11.79±0.04, 11.79±0.04 and 2.69±0.02 mg L^{-1}, respectively. **Conclusion:** The young leaves of *A. pauciflorum*, *S. oleana*, *M. indica*, *T. cacao* and *C. burmannii* can potentially be used as colourants in jelly drinks.

Key words: Antioxidant, jelly drink, natural dyes, red pigment, young leaves

Received: November 15, 2017 Accepted: July 10, 2018 Published: September 15, 2018

Citation: Tuty Anggraini, Vio Novendra and Novelina, 2018. Antioxidant activity of *Archidendron pauciflorum*, *Syzygium oleana*, *Mangifera indica*, *Theobroma cacao* and *Cinnamomum burmannii* Young Leaves and Their Application as Jelly Drink Colourants. Pak. J. Nutr., 17: 492-499.

Corresponding Author: Tuty Anggraini, Faculty of Agricultural Technology, Andalas University, 25163 Padang, Indonesia

Competing Interest: The authors have declared that no competing interest exists.

Data Availability: All relevant data are within the paper and its supporting information files.

INTRODUCTION

Jelly drinks are popular food products for all age groups as sources of carbohydrates, such as sugars, fibres and other components. Jelly drinks can be categorized as functional foods because of their health benefits. Jelly drinks usually have attractive colours that make the drink more desirable to consumers. Thus, the best dyes for food products are natural dyes. In addition to their function of making products more attractive, natural dyes are a source of biocompatible components that function as antioxidants. For example, anthocyanins in raspberry and blackberry have been shown to have the potential to inhibit cancer growth, particularly in colon and breast cancer[1,2].

Natural dyes such as anthocyanins, carotenoids, chlorophyll and betacyanin are derived from plants or animals. Natural dyes have been used in the food industry, but as technology develops, the use of synthetic dyes is also growing. Synthetic dyes are easier to obtain cheaply and many food manufacturers use these synthetic dyes to reduce production costs. However, the use of synthetic dyes is bad for human health[3,4].

According to Hii *et al.*[5] *Theobroma cocoa* contains bioactive compounds in the form of phenolic compounds, which have antioxidant properties. *Theobroma cocoa* leaves contain theobromine, caffeine, anthocyanin, leucoanthocyanidin and catechol at levels that vary by the age of the leaves and age of the plant. According to Ramirez *et al.*[6], gallic acid, quercetin, 3-D glucoside, tocopherol, 3-methyl-gallate, propyl gallate, propyl benzoate, catechin, epicatechin, benzoic acid and D-glucose are compounds present in *M. indica* leaves. In Indonesia, plants, such as *Archidendron pauciflorum* (*A. pauciflorum*), *Syzygium oleana* (*S. oleana*), *Mangifera indica (M. indica), Theobroma cacao* (*T. cacao*) and *Cinnamomum burmannii* (*C. burmannii*) are widely found and their fruits and other plant parts are usually consumed. Young leaves of *A. pauciflorum*, *S. oleana*, *M. indica*, *T. cacao* and *C. burmannii* plants can be potentially used as dyes because of their red colour. However, people have not used these young leaves as a colouring material. If viewed in terms of the young leaf colour, these plants can be used as a material for natural dyes that allegedly have an anthocyanin component. There is a lack of information about the use of the pigments of these young leaves, which has increased research interest in this topic.

Syzygium oleana plants are of concern due to the presence of phenol in their red shoots. According to Anggrani[7], the fruits and leaves of *S. oleana* contain antioxidants, such as total polyphenols and anthocyanins and can be applied to food products. The application of colourants in food products, such as jelly drink products, is very important. Jelly drinks are made of a gel-shaped liquid product that is easily aspirated, is chewy and can be consumed to delay hunger. Gels can be formed through formation of the junction zone by hydrocolloids (such as carrageenan) along with sugars and acids. Before their application in jelly drinks, the antioxidant activity of the young leaves is measured at various incubation times. Therefore, the purpose of this study was to evaluate the antioxidant activity, total polyphenols and anthocyanin content in *A. pauciflorum*, *S. oleana*, *M. indica*, *T. cacao* and *C. burmannii* young leaf extracts as well as their use in making jelly drinks.

MATERIALS AND METHODS

Materials: The materials used in this study are the young leaves of *A. pauciflorum*, *S. oleana*, *M. indica*, *T. cacao* and *C. burmannii*, sugar, water, seaweed and lime. Additionally, for chemical analysis, materials such as HCl, methanol, ethanol, Folin-Ciocalteu reagent and DPPH and the microbiological analysis used plate count agar (PCA) media.

Methods: This study used an exploratory method and the treatment involved the addition of *A. pauciflorum*, *S. oleana*, *M. indica*, *T. cacao* and *C. burmannii* young leaves into jelly drinks.

Creating the young leaf extracts: Young leaves of *A. pauciflorum*, *S. oleana*, *M. indica*, *T. cacao* and *C. burmannii* were sorted and then weighed and up to 300 g was then crushed and added to 150 mL of water and filtered. After filtration of the extract, it was evaporated with a rotary vacuum evaporator for 1 h.

Creation of the jelly drink: As much as 10 g of seaweed was then added to 200 mL of water and heated for 1 h at 100°C. After this mixture was filtered, 50 mL of seaweed and filtered water was added to a mixture of 0.5 mL of lime juice, 15% sugar and 10% young leaf extract.

Observations: The pH and antioxidant activity as well as total polyphenol and anthocyanin levels and colour (Hunter Lab) were measured for each of the jelly drinks containing the young leaf extracts (*A. pauciflorum*, *S. oleana*, *M. indica*, *T. cacao* and *C. burmannii*).

Antioxidant activity: Antioxidant activity was determined using the method originally developed by Blois[8]. A portion (0.1 mL) of the extracted solution (1.0 mg mL^{-1} methanol) for each young leaf of *T. cocoa*, *M. indica*, *A. pauciflorum*, *S. oleana* and *C. burmannii* extract and each jelly drink product were placed in a test tube and well mixed with 3.9 mL of methanol and 1.0 mL of a DPPH solution (1.0 mM in methanol). The mixture was stored at an ambient temperature for various incubation times (2, 15, 30, 45 and 60 min) prior to absorbance measurements at 517 nm (A517 nm). For the jelly drink product measurement, the incubation time was dependent on the results obtained for the optimal incubation time for the extract. All measurements were performed in triplicate.

$$\text{Antioxidant activity} = \frac{(\text{Control absorbance} - \text{Extract absorbance})}{\text{control absorbance}} \times 100$$

Total polyphenol test[9]: The stages of testing the total polyphenol content are as follows:

- One gram of the sample was weighed, placed in 10 mL of methanol and put into the vortex for 15 min
- Extract was brought up to 1 mL in volume
- Two millilitres of distilled water and 1 mL of Folin-Ciocalteu reagent were added
- Sample was vortexed for 5 min
- One millilitre of 5% Na_2CO_3 was added
- Reaction was allowed to proceed for 60 min in the dark
- Absorbance was measured at a wavelength of 725 nm

Anthocyanin content[10]: For analysis of the anthocyanin content, 1.86 g of KCl was placed in a beaker and distilled water was added to a final volume of approximately 980 mL. The pH was measured and adjusted to a pH of 1.0 (±0.05) with HCl (approximately 6.3 mL). Then, 1 L was transferred to a volumetric flask and diluted to a certain volume (1 L) with distilled water.

pH 4.5 buffer (sodium acetate, 0.4 M): Next, 54.43 g of $CH_3CO_2Na{\cdot}3H_2O$ was weighed in a beaker and distilled water was added to a final volume of approximately 960 mL. The pH was measured and adjusted to a pH of 4.5 (±0.05) with HCl (approximately 20 mL) and the solution was transferred to a 1 L volumetric flask and diluted with distilled water. The anthocyanin pigment concentration was then calculated and expressed as cyanidin-3-glucoside equivalents, as follows[10]:

$$\frac{\text{Anthocyanin pigment}}{(\text{cyanidin-3-glucoside equivalents, mg } L^{-1})} = \frac{A \times MW \times DF \times 100}{\varepsilon \times d}$$

Where:

A = (*A*520-A 700 nm) pH 1.0-(A520-A700 nm) pH 4.5
MW (molecular weight) = 449.2 g mol^{-1} for cyanidin-3-glucoside (cyd-3-glu)
DF = Dilution factor established in d
I = Pathlength in cm, = 26 900 molar extinction coefficient (ε), in L and mol^{-1} and cm^{-1}, for cyd-3-glu
103 = Factor for conversion from g to mg

RESULTS AND DISCUSSION

Analysis of the raw materials

Degree of acidity (pH): The pH of a material is measured to determine its acidity. Based on the analysis performed in this study, the pH values are presented in Table 1.

Table 1. Average Results of an Analysis of the Degrees of Acidity of *A. pauciflorum, S. oleana*, *M. indica*, *T. cacao* and *C. burmannii* Young Leaves.

Based on Table 1, the degree of acidity (pH) of the raw material ranged from 3.72-5.37. The level of acidity could influence the taste of the jelly drink. In addition to the taste, the acidity will affect the anthocyanin or other polyphenol stability. Diglycoside derivatives are more stable in neutral pH conditions, contrary to the aglycons[11]. Based on Table 1, *S. oleana* has the most acidic compounds, followed by *C. burmanii*, *M. indica*, *A. pauciflorum* and *T. cacao*. There is very little information available on the organic acid compounds of these plants, since the uses for the leaves of these plants are still unknown.

Antioxidant activity measured with DPPH: Antioxidant activity is a widely used term for a parameter that characterizes the ability of different substances and food samples to capture or neutralize free radicals.

Table 2 shows that *A. pauciflorum* has the fastest reaction time with DPPH, while *M. indica* and *T. cacao* need 30 min to react optimally with DPPH. *Cinnamomum burmannii* needs 45 min of incubation time and *S. oleana* needs 60 min of incubation time. *A. pauciflorum* has the highest antioxidant

Table 1: Average results of an analysis of the degrees of acidity of *A. pauciflorum*, *S. oleana*, *M. indica*, *T. cacao* and *C. burmannii* young leaves

Young leafs	pH±sd
Archidendron pauciflorum	5.23±0.01
Syzygium oleana	3.72±0.06
Mangifera indica	4.13±0.05
Theobroma cacao	5.37±0.01
Cinnamomum burmannii	4.33±0.02

Table 2: Antioxidant Activities of *A. pauciflora*, *S. oleana*, *M. indica*, *T. cacao* and *C. burmannii* young leaves at various incubation times

Incubation time (min)	Young leaf: *Archidendron pauciflorum* (%) ±sd	*Syzygium oleana* (%) ±sd	*Mangifera indica* (%) ±sd	*Theobroma cacao* (%) ±sd	*Cinnamomum burmannii* (%) ±sd
2	92.60±0.02	69.66±0.05	43.72±0.01	47.88±0.12	10.46±0.08
15	92.76±0.01	71.76±0.02	50.41±0.10	51.81±0.19	10.80±0.10
30	92.78±0.01	74.04±0.01	56.51±0.04	54.86±0.20	11.41±0.10
45	92.41±0.01	76.89±0.02	54.02±0.14	54.38±0.17	15.15±0.06
60	92.26±0.02	80.24±0.12	53.02±0.06	51.21±0.22	11.54±0.08

Table 3: Total polyphenol analysis of the young leaves of *A. pauciflora*, *S. oleana*, *M. indica*, *T. cacao* and *C. burmannii*

Young leaf	Total polyphenol (mg GAE g^{-1}) ±sd
Archidendron pauciflorum	1328.5±0.45
Syzygium oleana	905.0±0.03
Mangifera indica	639.5±0.11
Theobroma cacao	622.0±0.08
Cinnamomum burmannii	503.0±0.02

Table 4: Anthocyanin content in the young leaves of *A. pauciflora*, *S. oleana*, *M. indica*, *T. cacao* and *C. burmannii*

Young leaf	Anthocyanin (mg L^{-1}) ±sd
Archidendron pauciflorum	17.90±0.03
Syzygium oleana	19.34±0.02
Mangifera indica	74.39±0.07
Theobroma cacao	26.84±0.01
Cinnamomum burmannii	21.61±0.02

activity, followed by *S. oleana*, *T. cacao* and *M. indica* and the young leaves of *C. burmannii* had the lowest antioxidant activity. To measure the antioxidant activity in *A. pauciflorum,* 2 min was the optimal time. Therefore, based on the antioxidant properties in *A. pauciflorum*, the leaves can be classified as a fast-acting material that interacts with DPPH in a short time.

According to Anggraini[7], the optimal time to incubate DPPH with samples of *S. oleana* fruit is for 30 min. Some antioxidants react with DPPH in a short time, but other antioxidants are more reactive with DPPH. It is very important to identify the optimal time for incubation because each plant has a different type of antioxidant with different mechanisms of reaction with DPPH. The important role of anthocyanin in antioxidant activity depends on its pH as well as the proportion of protonated, deprotonated, hydrated and isomeric forms. The antioxidant activities of anthocyanin forms at a pH of 7 decrease in the following order: Cyanidin-3-rutinoside>malvidin-3-monoglucoside = delphinidin-3-mono-glucoside>petunidin-3-monoglucoside[12]. The leaves of *A. pauciflorum* are effective against hepatitis C virus and the chronic liver diseases it causes[13].

Total polyphenol analysis: The results of the total polyphenol analysis obtained from the raw materials of each young leaf are presented in Table 3.

Table 3 shows that the total polyphenol content ranged from 518-1328 mg GAE/g. *A. pauciflorum* has the highest total polyphenol content, while cinnamon has the lowest. The total polyphenol content has a positive correlation with antioxidant activity. Polyphenol compounds have an aromatic ring containing one or more hydroxy groups. The antioxidant activity of the phenolic compounds is related to that of the phenol compounds, where higher phenol compound content was followed by higher antioxidant activity. The total polyphenol content was responsible for the antioxidant activity, *A. pauciflorum* had the highest antioxidant activity, followed by *S. oleana*, *M. indica*, *T. cacao* and *C. burmanii*. An investigation of the leaves, peel, stem bar and kernel of mango showed that the total phenolic content ranged from 63.89-11.80 mg GAE g^{-1} in a distilled water solution and the flavonoid content ranged from 45.56-90.89 mg CE g^{-1} in a distilled water solution, mangiferin and quercetin were the antioxidants found in mango leaves[14,15].

Osman *et al.*[16] stated that cocoa leaves contain polyphenols that consist of epigalo catechin gallate (EGCG), epigallocatechin (EGC), epicatechin gallate (ECG) and epicatechin (EC). According to Al-Dhubiab[17], the dominant polyphenol compounds in *C. burmannii* are cinnamyl alcohol, coumarin, cinnamic acid, cinnamaldehyde, anthocyanin and essential oil. In addition, Prasad *et al.*[18] analyzed the antioxidant activity of the cinnamon species by high-performance liquid chromatographic analysis combined with an array diode detector (HPLC-DAD) and three flavonoid compounds, quercetin, kaempferol and quercitrin, were observed. According to Anggraini[7], the secondary metabolites found in *S. oleana* are anthocyanins.

Anthocyanin content: Anthocyanins have an optimum absorption at 500 nm, as the basic colours of red, blue and purple in plants are abundant in vegetables and fruits and other plants will degrade these colours at high temperatures to produce high-impact colour changes[16]. The anthocyanin content of the young leaves studied here can be seen in Table 4.

Table 4 shows that the young leaves of *M. indica* have the highest anthocyanin levels, while the lowest antioxidant

Table 5: pH Values of the jelly drinks

Jelly drink with the addition of young leaves	pH±sd
Archidendron pauciflorum	6.67±0.09
Syzygium oleana	5.10±0.01
Mangifera indica	6.26±0.26
Theobroma cacao	6.72±0.06
Cinnamomum burmannii	6.32±0.07

Table 6: Antioxidant activities of jelly drinks

Jelly drink with the addition of young leaves	Antioxidant activity (%) ±sd
Archidendron pauciflorum	67.56±0.08
Syzygium oleana	58.07±0.03
Mangifera indica	41.04±0.05
Theobroma cacao	33.56±0.16
Cinnamomum burmannii	10.52±0.07

levels are found in *A. pauciflorum*. There were differing results for antioxidant activity, *A. pauciflorum* has the highest antioxidant activity, which means that the antioxidant property in *A. pauciflorum* is conferred by another polyphenol that is not anthocyanin. Anthocyanins are water-soluble pigments that are naturally present in various plants. This pigment is the colour of fruit blossoms and the leaves of green plants. These pigments have been widely used as natural dyes in various food products and are important antioxidants with health benefits.

The anthocyanin content of these leaves will contribute to the colour of the jelly drink. In addition to appearance, the jelly drink colour has another function, it possesses functional properties due to its antioxidant compounds such as anthocyanin.

Results of the jelly drink analysis: Degree of Acidity (pH): The pH values for jelly drinks containing *A. pauciflora*, *S. oleana*, *M. indica*, *T. cacao* or *C. burmannii* young leaves are shown in Table 5.

Anthocyanin is a water-soluble pigment and the stability of factors such as pH (anthocyanin is degraded at pH levels above 7), temperature, light, the absence of co-pigment and the presence of enzymes, oxygen, vitamin C and sugar influences the colour[19]. Table 4 shows that the acidity of the leaves will contribute to the acidity of the jelly drink. Because all of the fruits have a pH value lower than 7, the addition of acid from another source is unnecessary. *S. oleana* is the most acidic leaf type.

Antioxidant Activity of Jelly Drinks Containing Leaves of *A. pauciflorum*, *S. oleana*, *M. indica*, *T. cacao* or *C. burmannii*: Consumption of jelly drinks containing *A. pauciflorum*, *S. oleana*, *M. indica*, *T. cacao* or *C. burmannii* young leaf extracts is associated with health benefits due to the antioxidant activity and presence of polyphenols, including anthocyanin.

Table 7: Total polyphenol content of the jelly drinks

Jelly drink with the addition of young leaves	Total polyphenols (mg GAE g^{-1}) ±sd
Archidendron pauciflorum	1095.5±0.07
Syzygium oleana	825.0±0.04
Mangifera indica	657.0±0.01
Theobroma cacao	524.0±0.03
Cinnamomum burmannii	477.5±0.02

Based on Table 6, the average antioxidant activity of jelly drinks ranged from 10.52-67.56%. The highest antioxidant activity (67.56%) was obtained from the addition of the young leaves of *A. pauciflorum*. The lowest antioxidant activity (10.52%) was obtained from the addition of young leaves from *C. burmannii*. Compared with the raw material, the antioxidant activity of the jelly drinks decreases after production, which is caused by antioxidant damage due to oxidation after exposure to air and cooking with high temperatures. In addition, the decrease in antioxidant activity is influenced by the amount of concentrated leaf extract added to the jelly beverage.

Plants contain structurally different antioxidant and antimicrobial phenolic compounds with different characteristics, such as stability. Caffeic, chlorogenic and gallic acid are unstable at a high pH, while chlorogenic acid is stable at an acidic pH under heat[20].

Total polyphenol content: Phenolic compounds in jelly drinks that contain various young leaves also contribute directly to antioxidant capacity. The total polyphenol contents of the jelly drinks produced in this study can be seen in Table 7.

Based on Table 7, the average total polyphenol content of a jelly drink containing young leaves ranges from 1095.5-477.5 mg GAE g^{-1}. Compared with the raw material, the total polyphenol content in jelly drinks decreases. This indicates that the processing adversely affects the total polyphenol content. Polyphenols are secondary metabolites of plants that have potential health benefits, as the dietary plant polyphenols offer protection against the development of cancer, cardiovascular diseases and other generative stresses[21]. Azulene, cylopentacycloheptane, azulene cylopentacycloheptene and phenol 2,2′-methylene bis[6-C1, 1-dimethylethyl]-4 ethyl are compounds found in the methanolic extract of *C. burmannii* leaves[22]. Epicatechin, epigallocatechin gallate and epicatechin gallate are the polyphenols present in the young leaves of *T. cacao*[16].

Anthocyanin content: Anthocyanin as a food dye is not only useful for improving the appearance of the product but is also very beneficial for health. The anthocyanin contents of

Table 8: Anthocyanin contents of the jelly drinks

Jelly drink with the addition of young leaves	Anthocyanin (mL L^{-1}) ±SD
Archidendron pauciflorum	6.90±0.02
Syzygium oleana	7.39±0.03
Mangifera indica	11.79±0.04
Theobroma cacao	5.95±0.05
Cinnamomum burmannii	2.69±0.02

Table 9: Colour of jelly drinks containing young leaves of *A. pauciflorum*, *S. oleana*, *M. indica*, *T. cacao* and *C. burmannii*

Young leaf extract	L^*	a^*	b^*	^{0}Hue	Colour
Archidendron pauciflorum	23.93	0.39	1.67	76.86	Red-Yellow
Syzygium oleana	21.76	7.92	6.44	39.16	Red
Mangifera indica	19.79	3.71	7.59	63.95	Red-Yellow
Theobroma cacao	25.42	2.38	10.70	77.46	Red-Yellow
Cinnamomum burmannii	26.55	-0.74	3.49	101.97	Yellow

jelly drinks containing the young leaves of *A. pauciflorum*, *S. oleana*, *M. indica, T. cacao* or *C. burmannii* are shown in Table 8.

Based on Table 8, the average anthocyanin content of the jelly beverages ranged from 11.79-2.69 mg L^{-1}. Anthocyanin was not significantly degraded at temperatures of 2.5-80°C but will degrade at temperatures above 80°C[16]. The most interesting characteristics of anthocyanin are its antioxidant and anti-inflammatory properties, which can help reduce the risk of cardiovascular disease and various diseases caused by oxidative stress[23].

Anthocyanin contributes to the colour of jelly drinks, the highest anthocyanin content was observed in *M. indica* extract, followed by *S. oleana*, *A. pauciflorum, T. cacao* and *C. burmanii*. Different results were obtained for their antioxidant activity, the highest antioxidant activity was found in *A. pauciflorum*. This indicates that anthocyanin does not contribute to the antioxidant activity of *A. pauciflorum*. Anthocyanin gives a purple colour to the jelly drinks and contributes to their functional properties[24,25].

Colour test: Colour is a property of food products that can be viewed as both a physical (objective) and an organoleptic (subjective) property. Colour is also an important attribute affecting the quality of jelly drinks. The colour of the jelly beverages containing natural dyes from various leaf sources was evaluated using a spectrophotometer (Hunterlab ColorFlex EZ), which yielded 3 colour parameters with L*, a* and b* notation. The resulting percentage values of the jelly drinks are presented in Table 9.

Based on Table 9, the colour analysis of jelly drinks is L* and ranges from 19.79-25.42, while a* ranges from -0.74-7.79 and b* ranges from 1.67-10.70. The resulting colour is also influenced by pH, a higher pH value resulted in a redder colour, which will also fade. According to Eiro and Heinonen[26], malvidin 3-glucoside solutions have the greatest co-pigmentation reactions, namely, the reaction of rosmarinic acid with malvidin 3-glucoside, which increases the colour intensity by 260%, while the addition of ferulic and caffeic acid increased the intensity of pelargonidin 3-glucoside. Anthocyanin is the major antioxidant of these young leaves, which have a stable condition for the flavylium cation when heated at 95°C at a pH of 1. Anthocyanin aglycones were degraded by scission into cyanidin-triglycosides, pelargonidin and cyanidin[27]. Therefore, the implication of this study is that the young leaves of *A. pauciflorum*, *S. oleana*, *M. indica*, *T. cacao* and *C. burmannii* can be applied to food products, but further studies are needed to determine the types of anthocyanin present in each young leaf.

SIGNIFICANCE STATEMENT

This study uncovered the potential for young leaves with red pigments to be used as colourants, which can be beneficial to increase the functional benefits of the plant in its application in food products. This study will help researchers uncover the critical properties of plants that can function as potential colourants, which many researchers have thus far been unable to explore.

CONCLUSION

The young leaves of *A. pauciflorum, S. oleana*, *M. indica*, *T. cacao* and *C. burmannii* show potential as colourants for jelly drinks. The results of this study showed that the antioxidant activity and total polyphenol content of *A. pauciflora* were the highest among the young leaves in both extracts and jelly drinks. The anthocyanin contents of

young leaves of *A. pauciflorum*, *S. oleana*, *M. indica*, *T. cacao* and *C. burmannii* were 17.90±0.03, 19.34±0.02, 74.39±0.07, 26.84±0.01 and 21.61±0.02 respectively, while the anthocyanin contents in *A. pauciflorum*, *S. oleana*, *M. indica*, *T. cacao* and *C. burmannii* jelly drinks were 6.90±0.02, 7.39±0.03, 11.79±0.04, 11.79±0.04 and 2.69±0.02, respectively. The young leaves of *A. pauciflorum, S. oleana*, *M. indica*, *T. cacao* and *C. burmannii* can potentially be used in jelly drinks as colourants.

ACKNOWLEDGMENT

This study was funded by the Faculty of Agriculture Technology, Andalas University, West Sumatra Indonesia.

REFERENCES

1. Bowen-Forbes, C.S., Y. Zhang and M.G. Nair, 2010. Anthocyanin content, antioxidant, anti-inflammatory and anticancer properties of blackberry and raspberry fruits. J. Food Comp. Anal., 23: 554-560.
2. Dai, J., A. Gupte, L. Gates and R.J. Mumper, 2009. A comprehensive study of anthocyanin-containing extracts from selected blackberry cultivars: Extraction methods, stability, anticancer properties and mechanisms. Food Chem. Toxicol., 47: 837-847.
3. Kamaljeet, S. Bansal and U. SenGupta, 2017. A study of the interaction of bovine hemoglobin with synthetic dyes using spectroscopic techniques and molecular docking. Front. Chem., Vol. 4. 10.3389/fchem.2016.00050.
4. Pivtsaev, A.A. and V.I. Razov, 2016. Detection of the carcinogenic properties of synthetic and natural dyes using positron annihilation lifetime spectrometry. Toxicol. Res., 5: 1306-1308.
5. Hii, C.L., C.L. Law, S. Suzannah, Misnawi and M. Cloke, 2009. Polyphenols in cocoa (*Theobroma cacao* L.). Asian J. Food Agro-Ind., 2: 702-722.
6. Ramirez, N.M., L.M. Farias, F.A. Santana, J.P.V. Leite and M.I. De Souza Dantas *et al*., 2016. Extraction of mangiferin and chemical characterization and sensorial analysis of teas from *Mangifera indica* L. leaves of the uba variety. Beverages, Vol. 2, No. 4. 10.3390/beverages2040033.
7. Anggraini, T., 2017. Antioxidant activity of *Syzygium*. Pak. J. Nutr., 16: 605-611.
8. Blois, M.S., 1958. Antioxidant determinations by the use of a stable free radical. Nature, 181: 1199-1200.
9. Wang, H., G.J. Provan and K. Helliwell, 2000. Tea flavonoids: Their functions, utilisation and analysis. Trends Food Sci. Technol., 11: 152-160.
10. Lee, J., R.W. Durst and R.E. Wrolstad, 2005. Determination of total monomeric anthocyanin pigment content of fruit juices, beverages, natural colorants and wines by the pH differential method: Collaborative study. J. AOAC Int., 88: 1269-1278.
11. Castaneda-Ovando, A., M. de Lourdes Pacheco-Hernandez, M.E. Paez-Hernandez, J.A. Rodriguez and C.A. Galan-Vidal, 2009. Chemical studies of anthocyanins: A review. Food Chem., 113: 859-871.
12. Muselik, J., M. Garcia-Alonso, M.P. Martin-Lopez, M. Zemlicka and J.C. Rivas-Gonzalo, 2007. Measurement of antioxidant activity of wine catechins, procyanidins, anthocyanins and pyranoanthocyanins. Int. J. Mol. Sci., 8: 797-809.
13. Hartati, S., C. Aoki, M. Hanafi, M. Angelina, P. Soedarmono and H. Hotta, 2018. Antiviral effect of *Archidendron pauciflorum* leaves extract to hepatitis C virus: An *in vitro* study in JFH-1 strain. Med. J. Indonesia, 27: 12-18.
14. Sultana, B., Z. Hussain, M. Asif and A. Munir, 2012. Investigation on the antioxidant activity of leaves, peels, stems bark and kernel of mango (*Mangifera indica* L.). J. Food Sci., 77: C849-C852.
15. Fernandez-Ponce, M.T., L. Casas, C. Mantell, M. Rodriguez and E.M. de la Ossa, 2012. Extraction of antioxidant compounds from different varieties of *Mangifera indica* leaves using green technologies. J. Supercrit. Fluids, 72: 168-175.
16. Osman, H., R. Nasarudin and S.L. Lee, 2004. Extracts of cocoa (*Theobroma cacao* L.) leaves and their antioxidation potential. Food Chem., 86: 41-46.
17. Al-Dhubiab, B.E., 2012. Pharmaceutical applications and phytochemical profile of *Cinnamomum burmannii*. Pharmacogn. Rev., 6: 125-131.
18. Prasad, K.N., B. Yang, X. Dong, G. Jiang, H. Zhang, H. Xie and Y. Jiang, 2009. Flavonoid contents and antioxidant activities from *Cinnamomum* species. Innovative Food Sci. Emerg. Technol., 10: 627-632.
19. Patras, A., N.P. Brunton, C. O'Donnell and B.K. Tiwari, 2010. Effect of thermal processing on anthocyanin stability in foods, mechanisms and kinetics of degradation. Trends Food Sci. Technol., 21: 3-11.
20. Cavalcanti, R.N., D.T. Santos and M.A.A. Meireles, 2011. Non-thermal stabilization mechanisms of anthocyanins in model and food systems-An overview. Food Res. Int., 44: 499-509.
21. Friedman, M. and H.S. Jurgens, 2000. Effect of pH on the stability of plant phenolic compounds. J. Agric. Food Chem., 48: 2101-2110.
22. Pandey, K.B. and S.I. Rizvi, 2009. Plant polyphenols as dietary antioxidants in human health and disease. Oxidative Med. Cell. Longevity, 2: 270-278.

23. Darmadi, A.A.K., D.N. Suprapta, I.G.R.M. Temaja and I.M.D. Swantara, 2017. GC-MS analysis of active compounds of cinnamon leaf extracts (*Cinnamomum burmanni* Blume). Int. J. Pharm. Bio Sci., 8: 409-415.
24. Martynenko, A. and Y. Chen, 2016. Degradation kinetics of total anthocyanins and formation of polymeric color in blueberry hydrothermodynamic (HTD) processing. J. Food Eng., 171: 44-51.
25. Miguel, M.G., 2011. Anthocyanins: Antioxidant and/or anti-inflammatory activities. J. Applied Pharm. Sci., 1: 7-15.
26. Eiro, M.J. and M. Heinonen, 2002. Anthocyanin color behavior and stability during storage: Effect of intermolecular copigmentation. J. Agric. Food Chem., 4: 7461-7466.
27. Sadilova, E., F.C. Stintzing and R. Carle, 2006. Thermal degradation of acylated and nonacylated anthocyanins. J. Food Sci., 71: C504-C512.