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Research Article

CHARACTERIZATION OF NUTRITION, ANTIOXIDANT PROPERTIES, AND TOXICITY OF *PHYSALIS ANGULATA* L. PLANT EXTRACT

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ABSTRACT

Objective: This research was to characterize and compare the nutrition, total phenolics (TP) content, antioxidant activity, and toxicity of all part of *Physalis angulata* L. extract.

Methods: The proximate, minerals, TP content, antioxidant activity, and toxicity of all parts of physalis, namely, stem bark extract of *P. angulata* L. (ESC), leaf extract of *P. angulata* L. (ELC), rind extract of *P. angulata* L. (ERC), unripe fruit extract of *P. angulata* L. (EUF), and ripe fruit extract of *P. angulata* L. (EFC), were analyzed. The TP content, total flavonoids (TF), and free radical scavenging activity of ethanolic extract are studied using Folin–Ciocalteu assay, aluminum chloride assay, and 1,1-diphenyl 2-picrylhydrazyl scavenging assay. Brine shrimp lethality bioassay (LC_{50}) used to measure the toxicity of extract.

Results: The physalis leaves extract (ELC) contains the highest total of phenolics (144.4 mg galiic acid equivalent/g), a total of flavonoids (33.33 mg quercetin equivalent/g), and antioxidant activity (96.97 µg/ml) followed by ERC>EFC>EUF>ESC. Based on the level toxicity of LC_{50}, the ripe fruit extract of *P. angulata* (EFC) (924.18 µg/ml) valued as cytotoxic.

Conclusion: The data of nutrition, antioxidant properties, and toxicity of all parts of *P. angulata* extract provide for functional food product uses.

Keywords: Antioxidant, Ciplukan, *Physalis angulata*, Phytochemical, Toxicity.

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INTRODUCTION

In Indonesia, in the past three decades, there has been an increase in the use of herbal medicine products and supplements. To improve the quality of health, 80% of the world population uses plant products [1]. Alternative therapy was developed by taking into bioactive compounds derived from nature. The biodiversity found in Indonesia is the world's second order. A total of 2500 of 30,000 plants are medicinal plants [2]. With biodiversity, it is potential to develop functional food products. In Indonesia, at 2009–2011, functional food products have an increased [3].

Globally, a nutritional transition has occurred from infectious disease patterns toward chronic and degenerative lifestyle-related diseases [4]. In Indonesia, changes in nutritional transition are reinforced by increased non-communicable diseases, such as hypertension from 7.6% in 2007 to 9.5% in 2013; stroke from 8.3/1000 to 12.1/1000 (2013); and diabetes mellitus from 1.1% (2007) to 2.1% (2013) [5]. One of the utilizations of traditional medicine based on local wisdom is using a plant named *Physalis angulata* Lour.

P. angulata L. (Indonesia: "*Ciplukan*" or Sundanese: "*Cecendet*"), family Solanaceae, empirically already utilized in Sundanese traditional medicine preparation for recovery "kencing manis" (diabetes mellitus). Previous studies have reported that physalis leaves possess an anti-diabetic effect [6]. According to Pinto *et al*. [7], the ethanolic fruit extract of physalis has given anti-hyperglycemic and anti-hypertension potential. Moreover, the ethanolic crude extract of the fruit of physalis has a role in the immune system (immunomodulation), anti-inflammation effect, and antioxidant activity [8,9].

The utilization of local wisdom, increased demand, and many benefits obtained from physalis make it potentially functional food [9]. However, there are still challenges that must be faced, such as poor quality control of extract (non-standard), the lack of clinical and pharmacological data, and toxicity [10]. Nevertheless, based on our knowledge, the evaluation of characteristics antioxidant activity and toxicity of all parts of physalis remain scarce. The present study focused on evaluation and comparison of the characteristics of the nutrition, total phenolics (TP) content, antioxidant activity, and toxicity of all part of P. angulate Lour. Based on the results of the research, there was an effect of TP content against free radical scavenging activity at physalis extract.

MATERIALS AND METHODS

Reagents and materials

Folin-Ciocalteu's phenol reagent, 1,1-diphenyl 2-picrylhydrazyl (DPPH), gallic acid, quercetin was obtained from Sigma-Aldrich (Singapore). *Artemia salina* L. larva (Hobby Artemix) was purchased from Dohse Aquaristik GmbH and CO. Gelsdorf, Germany. Aluminum chloride, ethanol, sodium hydroxide, and sodium carbonate are obtained from Merck, Tbk. All reagent used is an analytical grade. Fresh *P. angulata* L (physalis) was collected from Rawalele village – Subang, Indonesia, obtained from January to May 2018 (Fig. 1). Botanical authentication was done by a Botanist from "Herbarium Bogoriense," Research Center for Biology, Indonesian Institute of Sciences (No. 886/IPH.1.01/If.07/IV/2018), with the voucher specimen that has been stored.

Sample preparation

Fresh physalis washed, then dried at 45°C in 3 days and smashed into powder, the powder soaking in ethanol with ratio 1:10 for 24 h by maceration methods (3 times). The filtrates were consolidated and dried by a vacuum evaporator. For analysis, 10 ml of ethanol was added into a centrifugation tube containing 0.06 g of physalis ethanol extract. The samples centrifuged for 10 min after shaking. The resulting

Fig. 1: *Physalis angulata* Lour

supernatant was inserted into a 10 mL volumetric flask and added ethanol to the limit mark and shaken for 10 min [11].

Procedure analysis

Physical and nutritional composition

Physical composition, namely, yield, pH, total solid, and color was performed in triplicate. The nutrition composition, viz., moisture, ash, carbohydrates, protein, and lipid content, was measured by methods described [12]. Atwater factor used as a direct application in measuring the energy, which 1 g carbohydrate=4 kcal; 1 g lipid=9 kcal; and 1 g protein=4 kcal. Colorimeter 3 nh is needed to determine the total color difference of the three coordinates.

Preliminary phytochemical screening

Physalis powder was the identification of saponin, flavonoid, alkaloids, tannin, glycosides, and sterols or terpenoids [13-15].

Total carotenoids content

Total carotenoid content of the extract studied with methods of Scrob *et al*. [16]. The extract of physalis was re-extracted with petroleum ether. The total carotenoid content of the samples was analyzed at λ=450 nm using a ultraviolet (UV)-VIS spectrophotometer (UV-1700 Shimadzu series) in units of μg/g (the absorbance should be between 0.2 and 0.8).

TP content

The TP content of physalis was analyzed with the Folin-Ciocalteu assay [17]. The 100 μl extract or standard solution of gallic acid or blank (0; 25; 50; 100; 150; and 200 μg/ml) has been added with distilled water (2.8 ml) and sodium carbonate (2 ml and 2%), and allowed to stand for 4 min. The 100 μl of Folin-Ciocalteu solution was added, then silence for 30 min. Measurement of blank solution was carried out at λ=760 nm. Total phenol is calculated based on equation one expressed in mg gallic acid equivalent (GAE) in grams of dry weight of plant extracts (R^2:0.994). The samples were analyzed in three replications.

$$\text{Absorbance} = 0.0005 \text{ galiic acid} \frac{\mu g}{mL} - 0.0033 \quad (1)$$

TF content

The TF content of physalis was determined using aluminum chloride assay [18]. The 1 ml extract or standard solution of quercetin or blank (0; 25; 50; 100; and 200 μg/ml) has been added with aluminum chloride (2 ml and 2%) in methanol solution. It was then mixed with vortex and allowed to stand for 30 min. Measurement of blank solution was carried out at λ=415 nm. Flavonoid calculations according to the equation of two expressed in mg quercetin equivalent (QE) in gram dry weight of plant extracts (R^2:0.993). The samples were analyzed in three replications.

$$\text{Absorbance} = 0.0081 \text{ quercetin}(\frac{\mu g}{mL}) + 1.594 \quad (2)$$

Antioxidant activity

Analysis of antioxidant activity in physalis extracts using the method [19]. The extract solution at concentrations is not the same (1 ml) or blank or standard solution has been added with 3 ml of 0.004% DPPH methanolic solution then stored in the dark for 30 min. Measurement of blank solution was carried out at λ = 517 nm. Data obtained were calculated by expression (30) and delivered as the concentration of antioxidants needed for 50% DPPH radical scavenger in a defined time period (IC_{50}). The samples were analyzed in three replications.

$$\% \text{ Inhibition} = \left[\frac{(Ac - As)}{Ac}\right] \times 100 \quad (3)$$

Where:
Ac = absorbance control or blank,
As = absorbance with sample or standard.

Cytotoxicity assay

The cytotoxicity of the ethanolic extract of physalis was investigated by brine shrimp lethality bioassay [20]. Brine shrimp that are hatched is obtained from brine shrimp eggs (Hobby Artemix®, Germany), which is mixed with salt, in a conical shaped vessel, for 48 h they were left in sterile distilled water under constant aeration. Using a capillary glass of ten active nauplii is taken and put into a bottle containing 4.5 ml of brine solution. The 0.5 ml of the ethanolic extract has been added with brine solution (4.5 ml) and stored under light at room temperature for 24 h, and surviving larvae were counted. After incubation, the larvae are counted dead and live in each test. The research was controlled (vehicle-treated) at unequal concentrations (1–1000 μg/ml) with test substances per dose of a set of three tubes. The LC_{50} values are used to determine the mortality rate of larvae up to 50%, were calculated using probity analysis. Estimated linear correlations were observed when the logarithm of concentration.

Statistical analysis

Data were presented in means±standard deviation and tested for normality. The differences between treatments were analyzed using ANOVA. Significant differences between mean values were calculated using the Duncan Multiple Range Test (α=5%). All statistical analysis was performed using Microsoft Excel 2013.

RESULTS

Nutrition and physicochemical characteristics

The nutrition and physicochemical characteristics of each part of *P. angulata* L. are displayed in Tables 1 and 2.

Table 2 showed physicochemical characteristics of each part of physalis with the pH value ranging from 5.81 to 6.46, and the total solid ranging from 5.16 to 6.86° Brix. The color of each part of *P. angulata* used a colorimeter 3 nh to find out the spectrum of reflection of the sample, so we get the color coordinates of CIE L* a* b* coordinates and hue (h*) (Table 2). Table also shows that the colors of each part of physalis were darker, greener, and less blue, except for fruit and stem bark powder. The plant cell walls breakdown is related to the extracts obtained. The yields of ethanolic extract of each part of physalis ranged from 2.0 to 3.6% (Fig. 2).

Phytochemical screening

Phenolic compounds in *P. angulata* L. ethanolic extracts are found in large quantities in the phytochemical screening process, which proven by the existence of alkaloids terpenoids, tannins, flavonoids, and glycosides. Phytochemical screening is shown in Table 3.

Table 1: Nutrition composition of *P. angulata* L. powder

Constituent	Part of the plant				
	ESC	ERC	ELC	EUF	EFC
Moisture (%)	6.04±0.41^{e}	14.31±0.51^{a}	9.30±0.81^{bc}	8.60±0.28^{d}	9.38±0.40^{bc}
Ash (%)	0.87±0.01	0.91±0.00	0.90±0.01	0.85±0.03	0.87±0.01
Protein (%)	10.75±0.00^{d}	14.06±0.00^{a}	2.98±0.00^{e}	17.10±00^{b}	13.72±0.00^{c}
Lipid (%)	4.10±0.13^{de}	7.39±0.35^{c}	11.28±0.35^{a}	3.65±0.11^{de}	9.81±0.50^{b}
Carbohydrates (%)	78.24±0.14^{a}	63.34±0.22^{e}	75.54±0.23^{b}	69.80±0.10^{c}	66.22±0.23^{d}
Energy (kcal)	392.86±1.73	375.99±4.03	415.60±4.07	380.45±1.39	408.05±5.42

Data are expressed as mean±standard deviation (n=3). ESC: Stem bark extract of *Physalis angulata* L., ELC: Leaf extract of *Physalis angulata* L., ERC: Rind extract of *Physalis angulata* L., EUF: Unripe fruit extract of *Physalis angulata* L., EFC: Ripe fruit extract of *Physalis angulata* L. a>b>c>d>e, the existence of the same letter in the same line is expressed as the absence of difference. *P. angulata* L.: *Physalis angulata* Lour

Table 2: Physicochemical characteristics of *P. angulata* L.

Samples	pH	Total solid (Brix)	Color (Δ)				
			L*	a*	b*	Hue	Preference
ESC	6.59	6.86	59.817	−2.788	14.927	+0.003	Darker, greener, more yellow
ERC	6.46	5.56	53.498	3.492	15.903	+0.004	Darker, less red, more yellow
ELC	6.33	5.16	48.410	−2.168	9.593	+0.003	Darker, greener, less blue
EUF	5.81	5.36	55.811	7.142	19.770	+0.003	Brighter, less red, more yellow
EFC	6.01	6.56	55.811	7.142	19.770	+0.003	Brighter, less red, more yellow

Data are expressed as mean (n=3). ESC: Stem bark extract of *Physalis angulata* L. , ELC: Leaf extract of *Physalis angulata* L., ERC: Rind extract of *Physalis angulata* L., EUF: Unripe fruit extract of *Physalis angulata* L., EFC: Ripe fruit extract of *Physalis angulata* L. a>b>c>d>e, the existence of the same letter in the same column is expressed as the absence of difference. *P. angulata* L; *Physalis angulata Lour*

Total carotenoids content

The result of the total carotenoids of each part of a *P. angulata* extract is presented in Fig. 3. Fig. 3 showed that total carotenoid compounds contained in the extract range between 6.83 and 20.22 µg/g extract.

TP content, TF content, and antioxidant activity (IC_{50})

The results of the quantitative analysis support the results of previous phytochemical screening, where leaf extracts have a high amount of phenolics compounds. The TP, TF, and antioxidant activity (IC_{50}) are shown in Table 4. Table 4 showed that ethanol extract of *P. angulata* has TP content ranged from 15.43 to 144.33 mg GAE/g dry weight. The level of antioxidant activity was interrelated with the level of TP content of (R^2) 0.857 (Fig. 4). The results of the study showed that with the high content of total phenols, the stronger the antioxidant activity (with the lowest of IC_{50} values).

Cytotoxicity

The cytotoxicity (LC_{50}) brine shrimp lethality test of ethanolic extract of each part of the physalis plant evaluated is summarized in Table 5.

DISCUSSION

This study shows that the ethanolic rind extract of *P. angulata* L. (ERC) had the highest moisture and protein content than other parts ($p<0.05$) (Table 1). The protein of the fruit of *P. pubescens* L. was 31.8% [21]. Moreover, the fruit of *Physalis peruviana* has better protein contains [22]. The leaf extract of *P. angulata* L. (ELC) contained the highest lipid content (11.28%) followed by EFC>ERC>unripe fruit extract of *P. angulata* L. (EUF) and stem bark extract of *P. angulata* L. (ESC) ($p<0.05$). According to Ramadan and Mörsel [23], the fruit of *P. peruviana* L. contains 2% lipid content, which is 1.8% (seeds) and 0.2% (fruit skin). The high content of polyunsaturated fatty acids obtained from peruviana, which has been extracted into oil [23]. A phytochemical in extract plant maintained in pH value 3–11 and antioxidant activity influenced by pH [24,25]. ANOVA displayed that the ethanolic extract of the fruit of P. angulata, namely, EUF and EFC, with the highest average values in yields is ESC>ERC and ELC ($p<0.05$) (Table 2).

Table 3 is displayed that leaves and fruit extracts of *P. angulata* have various phenolic compounds. Alkaloids compounds were not in ethanolic extract of physalis. The results of this study are an agreement with methods of Andrianto *et al.* [26], the ethanolic extract of *P. peruviana* leaves contained phenol, flavonoids, tannins, saponins, steroids, and terpenoids. The stem barks of *P. angulata,* obtained by

Table 3: Phytochemical screening of *P. angulata* L.

Constituent	ESC	ERC	ELC	EUF	EFC
Alkaloids					
Mayer	–	–	–	–	–
Terpenoids	++	++	++++	++	+++
Saponin	+	–	++	–	–
Tannins	++	+++	++++	+	+++
Flavonoids	+	++	+++	+	++
Glycosides	–	++	++++	+	+++

(+) means positive; (−) means negative. ESC: Stem bark extract of *Physalis angulata* L. , ELC: Leaf extract of *Physalis angulata* L., ERC: Rind extract of *Physalis angulata* L., EUF: Unripe fruit extract of *Physalis angulata* L., EFC: Ripe fruit extract of *Physalis angulata* L., *P. angulata* L.: *Physalis angulata* Lour

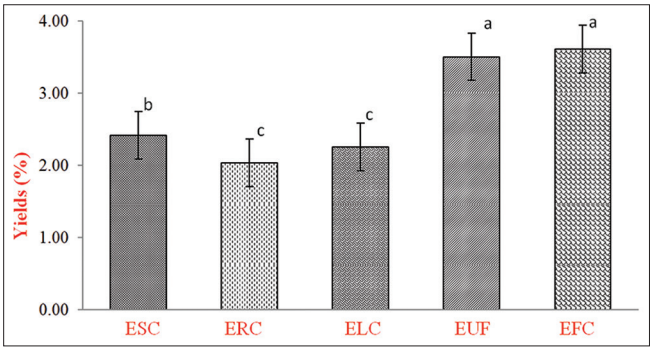

Fig. 2: Yields of ethanolic extracts of *Physalis angulata* L. Data were expressed as means±standard deviation (n=3). ESC: Stem bark extract of *P. angulata* L., ELC: Leaf extract of *P. angulata* L., ERC: Rind extract of *P. angulata* L., EUF: Unripe fruit extract of *P. angulata* L., EFC: Ripe fruit extract of *P. angulata* L. a>b>c, same alphabetic in the graphic=no difference

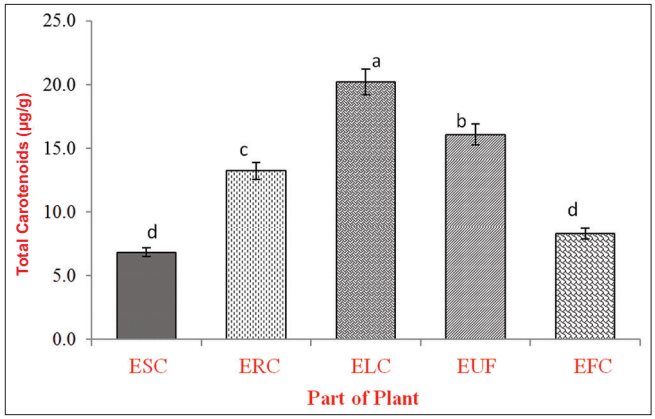

Fig. 3: Total carotenoid of ethanolic extracts of *Physalis angulata* L. Data were expressed as means±standard deviation (n=3). ESC: Stem bark extract of *P. angulata* L., ELC: Leaf extract of *P. angulata* L., ERC: Rind extract of *P. angulata* L., EUF: Unripe fruit extract of *P. angulata* L., EFC: Ripe fruit extract of *P. angulata* L. a>b>c>d, same alphabetic in the graphic=no difference

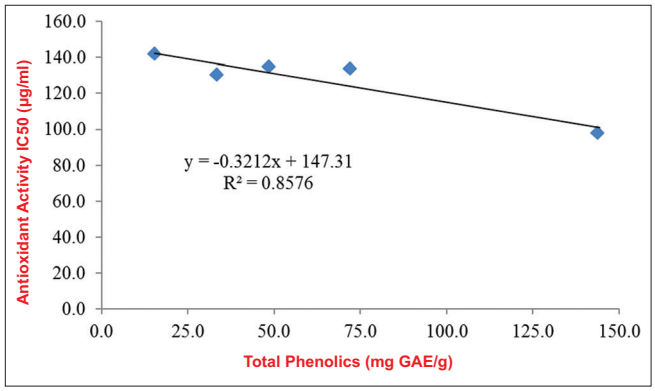

Fig. 4: Relationship between total phenolics content and antioxidants activity of *Physalis angulata* extract in several parts (n=3)

various extraction methods, contained phenol, flavonoid, and tannin compounds [27].

The leaves extract of *P. angulata* (ELC) there is a high amount of total carotenoids (20.22 µg/ml) followed by EUF>ERC>ESC and EFC ($p<0.05$) (Fig. 3). This result is in agreement with methods of Mier-Giraldo *et al*. [28] who studied that total carotenoid of fruit extract of *P. peruviana* L. ranged between 1.28 and 4.91 µg/g extract. Our findings show that most carotenes found in leaves and fruit extracts.

Meanwhile, Table 4 shows that stem bark from *P. angulata* by extraction process has the lowest TP content. The TP content in physalis influenced by the polarity of solvents and part of the plant used in the extraction process. Every part of the plant such as leaves, fruit, or roots has various types of phytochemical compounds [9]. Table 4 shows that each part of *P. angulata* has a dissimilar in TP content. The highest of a TP content shows in leaves extracts of *P. angulata* (144.33 mg GAE/g dwt) followed by ERC>EUF>EFC>ESC ($p<0.05$). Moreover, the TF content in high amounts derived from the leaf extract *P. angulata* (ELC) (33.33 mg QE/g dwt) where the scale of TF to TP at 0.23, followed by ethanol extract of EUF>EFC>ERC>ESC ($p<0.05$) (Table 4). DPPH free radical inhibition of the ethanol extract *P. angulata* depends on the concentration where the value is expressed as IC_{50}. Based on the results of an analysis of antioxidant activity contained in the ethanolic leaves extract of physalis (ELC), has a high antioxidant activity value with the lowest IC_{50} value (Table 4). However, the resulting activity remains below the standard gallic acid or ascorbic acid. The extent of the TP

Table 4: TP, TF content, and antioxidant activity of ethanolic extract of *P. angulata* L.

Samples	TP (mg GAE/g)	TF (mg QE/g)	TF: TP	IC_{50} (µg/ml)
ESC	15.43±1.88^{e}	9.04±0.04^{e}	0.58	141.07
ERC	72.27±4.95^{b}	10.67±0.45^{cd}	0.15	133.76
ELC	144.33±0.00^{a}	33.33±0.00^{a}	0.23	96.97
EUF	33.60±1.18^{d}	22.41±0.00^{b}	0.67	129.25
EFC	48.77±0.94^{c}	11.91±0.35^{c}	0.24	134.53

Data are expressed as means±standard deviation (n=3). GAE: Gallic acid equivalent; QE: Quercetin equivalent. ESC: Stem bark extract of *Physalis angulata* L., ELC: Leaf extract of *Physalis angulata* L., ERC: Rind extract of *Physalis angulata* L., EUF: Unripe fruit extract of *Physalis angulata* L., EFC: Ripe fruit extract of *Physalis angulata* L. a>b > c>d > e, the existence of the same letter in the same column is expressed as the absence of difference. TP: Total phenolics, TF: Total flavonoids, *P. angulata* L.: *Physalis angulata* Lour

content of *P. angulata* affects free radical scavenging activity.

Phenolic compounds are known to possess antioxidant activity that can bind active oxygen species and electrophiles [29]. Fig. 4 shows that antioxidant activity of P. angulate of 86% derived from phenolic compounds, meanwhile 14% obtained from carotenoids, vitamin, etc. This result in accordance with methods of Maisuthisakul *et al*. [30] that in 28 Thai plant ethanol extracts showed a close involvement among antioxidant activity and TP. Furthermore, another study said that the different crops there are also similarities correlation analysis [31].

The ethanolic extract of each part of the physalis tested showed non-toxic activity (LC_{50} value more than 1000 µg/ml). Meanwhile, not for ripe fruit extract of *P. angulata* L. (EFC) having a value of LC_{50} <1000 µg/ml) [20]. The LC_{50} values of ethanolic extract for ESC, ERC, ELC, EUF, and EFC were 2297 µg/ml, 2181 µg/ml, 2024 µg/ml, 1682 µg/ml, and 924 µg/ml, respectively. However, the ethanol extract of *physalis* has a low value when compared with the amount of value to other plants, except leaves or fruit part of physalis [32,33]. According to Kormin *et al*. [34], variations in temperature during the process may affect poorly extracted LC_{50} values. It may be due to the denaturing of some bioactive compounds and other reasons that may only be active when its fresh. The cytotoxic property by ethanolic extract of physalis ripe fruit (EFC) might be due to the presence of a good amount of flavonoid content. A large number of flavonoids in physalis material have reported as anti-hyperglycemia and anti-hypertension, immunomodulation and anti-inflammation effect, and antioxidant activity [7-9].

In the current study, we found that a ripe fruit extract of physalis (EFC) displayed the toxicity with the highest value against *A. salina* brine shrimp larvae at lower LC_{50} values. The results of this study stated that potential cytotoxic compounds could indicate from the ethanol extract of *P. angulate* L.

CONCLUSION

The *P. angulate* L. has good nutritional characteristics that contain bioactive compounds that provide health benefits. In color, the powders of each part of physalis were darker, greener, and less blue, except for fruit and stem bark powder. The leaves extract of physalis (ELC) contained the highest total of phenolics and total of flavonoids with a ratio of TF/TP, which is 0.23. ELC is found to have the highest antioxidant activity (EC50) followed by ERC>EFC>EUF>ESC. The TP content of extract of physalis has a strong correlation with antioxidant activity. Based on the toxicity test (LC50), the ripe fruit extract of physalis (EFC) as cytotoxic. These results provide useful data about the nutritional, antioxidant properties, and toxicity of ethanolic extract of each part of *physalis* for functional food product uses.

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AUTHORS' CONTRIBUTIONS

Ade Chandra Iwansyah (ACI) and Rohmah Luthfiyanti designed and conducted field research; Wahidiyanti P Julianti performed laboratory analysis; ACI conducted statistical analyses; ACI wrote the manuscript with inputs from all coauthors; ACI had final responsibility for the content. All authors read and approved the final manuscript.

CONFLICTS OF INTEREST

There are no conflicts of interest in this paper.

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