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EVALUATION OF THE USE OF DIFFERENT SOLVENTS FOR PHYTOCHEMICAL CONSTITUENTS AND ANTIOXIDANTS ACTIVITY OF THE LEAVES OF *MURRAYA KOENIGII* (LINN.) SPRENG. (*RUTACEAE*)

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ABSTRACT

Murraya koenigii (Rutaceae) is a promising source of bioactive compounds since the leaves of this plant has been traditionally used extensively in the Indian Ayurvedic system of medicine for the treatment of a wide range of diseases and disorders. Although the pharmacological effect of the plant's bioactive compounds has been extensively studied, however, study on the effect of using different extraction solvents to extract these bioactive componentsis scarce. The aim of the present study was to evaluate the impact of different solvents on extraction yields, phytochemical constituents and antioxidants activity of dehydrated *Murrayakoenigi* leaves. The results showed that the used solvents play an important role in the yield of extraction and the content of chemical components. Methanol was identified as the most effective solvent for the extraction, resulting in the highest extraction yield (5.70%) as well as the highest content of phenolic (27.2 mg GAE/g DW) and flavonoid (15.55 mg QE/g DW). The extract obtained from methanol exhibited highest antioxidant scavenging activity (93%), (using 2,2-diphenyl-1- picrylhydrazyl (DPPH) free radical scavenging assay), and the antioxidant activity of *Murraya koenigi* leaves extract was found to be higher than ascorbic acid. Therefore, methanol is recommended as the optimal solvent to obtain high content of phytochemical constituents as well as high antioxidants constituents from *Murraya koenigi leaves* for utilization in pharmacognosy. To best of our knowledge this is the first report that directly compares these 4 extraction solvents for the extraction of bioactive components from *Murraya koenigi leaves*.

Keywords: *Murraya koenigi*, Phytochemicals, Antioxidants, Solvents

INTRODUCTION

The human body possesses complex antioxidant defense systems that make use of antioxidant enzymes like superoxide dismutase, catalase and glutathione peroxidase, and non-enzymatic antioxidants like vitamins C and E, thiol antioxidants, glutathione, carotenoids and melatonin. Nearly all organisms have antioxidant and repair systems to protect themselves against oxidative damage however, these systems cannot fully prevent damage (Subedi *et al.,* 2014; Magalhães *et al.,* 2014; Ke *et al.,* 2009). This insufficiency may result in oxidative stress.

Reactive oxygen species (ROS) that are produced as a result of cellular metabolism are highly toxic and are involved in the etiology of many chronic diseases such as neurodegenerative and autoimmune diseases, cardiovascular disease, chronic obstructive pulmonary disease, rheumatoid arthritis, asthma, and some cancers (Huang *et al.,* 2016; Deng *et al.,* 2011; Cai *et al.,* 2004) because of oxidative damage to lipids, nucleic acids and proteins. Even though an internal system of antioxidant exists in our body but exogenous antioxidants are recommended to get rid of excessive free radicals (Yanishlieva *et al*., 2006). Antioxidants can be natural and synthetic, but due to toxic and carcinogenic effects, synthetic antioxidants, such as butylhydroxyanisole, butylhydroxytoluene, gallic acid esters, and tertiary butylated hydroquinone, are being replaced with natural antioxidants (Botterweck *et al*., 2000).

Medicinal plants contain a wide variety of phytochemicals, such as alkaloids, tannins, flavonoids, terpenoids, saponins , phenolic compounds, anthocyanins, carotenoids, dietary glutathione, vitamins, and endogenous metabolites that can have high antioxidant activities. Therefore, current researches are directed towards naturally occurring bioactive compounds from sources such as plants (Jiménez *et al.,*2015). Plant phytochemicals act against free radical induced oxidative stress and do not have the side effects of synthetic antioxidants (Subedi *et al.,* 2014; Atala et al., 2009). Isolation of compounds from plant extracts that are responsible for reducing cellular oxidative stress can be done and then used for development of drugs for the prevention and treatment of numerous human diseases (Choi *et al.,* 2002).One such example of the medicinal plants mainly applied as food or nutraceuticals for various pharmacological activities is *Murraya koenigii.*

Murraya koenigii (L.) Spreng, commonly known as curry leaf, belongs to the family *Rutaceae*, which is native tonative of India, Sri Lanka and other south Asian countries (Satyavati, 1987). Curry leaf has a slightly pungent, bitter, and feebly aciduloustaste and is widely used for cooking in India and otherAsian countries. Aromatic bioactive constituents in the leaves of *Murraya koenigii* retain their flavor and other qualities, even after drying (Yankuzo *et al*., 2011; Husna *et al*., 2018; Amna *et al*., 2019; Yeap *et al*., 2015; Nooron *et al*., 2017; Das *et al*., 2014).For centuries, this plant has been used in diverse forms and holds a place of pride in Indian Ayurvedic medicine, called "krishnanimba" (Ahluwalia *et al*., 2014). *Murraya koenigii* leavescontain several interesting bioactive compoundswith health-promoting properties (Satyavati *et al*., 1987). Different parts of *Murraya koenigii* have been used in traditional Ayurveda medicinefor the treatment of hepatitis, hypertension, cough, hysteria, skin eruptions, rheumatism and poisonous bites. Additionally, curry leaf has been reported to have antitumor (Ito *et al.,* 2006), antioxidant (Mohd Nor *et al*., 2009), anti-inflammatory (Muthumani *et al*., 2009), antihyperglycemic (Dineshkumar *et al.,* 2010), and hypoglycemic effects (Tembhurne and Sakarkar, 2009), Anticancer (Ghasemzadeh *et al.,* 2014). It is also used as antihelminthics, analgesics, digestives (Bhandari, 2012; Desai *et al*., 2012), Wound healing, Hepatoprotective, Nephroprotective, Cardioprotective, Neuroprotective, Antifungal, Immunomodulatory, Antimicrobial (Balakrishnan *et al.,* 2020).

The main process by which bioactive compounds may be obtained from biomass materials is referred to as extraction. The objective of extraction process is to maximize the amount of target compounds and to obtain the highest biological activity of these extracts (Chang *et al.,* 2002). The extraction yield and biological activity of the resulting extract is not only affected by the extraction method but also by the extraction solvent (Ajanal *et al.,* 2012; Mahdi-Pour *et al.,* 2012). Extracting bioactive compounds from the plant material have been carried out using many solvents, including methanol, ethanol, acetone, and water. Due to the variety of bioactive compounds contained in plant materials and their varying solubility properties in different solvents, the optimal solvent for extraction depends on the particular plant materials, and the compounds that are to be isolated (Ajanal*et al.,* 2012; Mahdi-Pour *et al.,* 2012). Thus, recommendation of appropriate extraction solvent for individual plant materials is generally problematic. For *Murraya koenigii*, most research has focused on the screening and quantification of bioactive compounds. Several works reporting screening and quantification of bioactive compounds, pharmacological and medicinal uses of *Murraya koenigii* abound in the scientific literature. However there is paucity of dataregardingthe effect of solvent on the bioactive compounds extraction from *Murraya koenigii* leaves.

The aim of the present study was to examine the effect of distilled water and organic solvents (methanol, ethanol and chloroform) on the extraction yield and the content of phenolics and flavonoids. The antioxidant activity of the resulting extracts was also investigated.

MATERIALS AND METHODS

Chemicals

Methanol, ethanol, chloroform, Folin-Ciocalteu, quercetin, ascorbic acid, 2,2-Diphenyl-1-picrylhydrazyl (DPPH), and other reagents were analytical grade was provided by Sigma-Aldrich, Singapore.

Collection of the plant sample and extract preparation

Fresh healthy leaves of *Murraya koenigii*were collected from the University (Sam Higginbottom University of Agriculture Technology and Sciences) farm and were taxonomically identified. The fresh leaves were thoroughly washed, rinsed with distilled water for the removal of dirt. The samples were air dried to a constant weight, in the shade where there was no sun exposure, and then pulverized, crushed into fine powder using a manual blender and weighed.Crushing the vegetables disrupts cell matrices, exposing the compounds within them, thereby enhancing the extraction of more phytochemicals. The powder was bottled in well-labeled airtight containers for later use in qualitative and quantitative analysis of phytochemicals in the *Murraya koenigii* leaves.

Extraction methods

The powdered leaves samples were extracted using distilled water and organic solvents (methanol, ethanol and chloroform) prior to performing qualitative and some quantitative tests as described below.

Methanolic, Ethanolic and Chloroform extraction

The preparation of methanolic extracts was performed by the addition of absolute methanol (20 ml) to 2.0 g of the powdered samples for 72 h. The samples were then filtered using Whatman No. 1 filter paper and filtrates from the filtration procedure were left to evaporate at room temperature. The dried residues (50 mg) were re-dissolved in 20 ml of absolute methanol and stored at 4 °C (De *et al.,* 2010). Similar analysis as mentioned (for methanol) above was performed to obtain Ethanolic and Chloroform extracts respectively.

Aqueous extraction (Distilled water)

2.0 g of powdered samples was dissolved in 60 ml of distilled water overnight. Filtration was done using Whatman No. 1 filter paper and the filtrate was stored in vials at 4 °C, whilst the residue was discarded (De *et al.,*

2010).

2.4. Determination of Extraction Yield. The extraction yield (%) was calculated as follows:

Extraction yield

$$(\%) = \frac{\text{weight of the extract after evaporating solvent}}{\text{dry weight of the sample}} \times 100 \quad ...(1)$$

For qualitative and quantitative phytochemical analysis, tests were performed using the extracts from various solvents.

Preliminary qualitative screening tests for the presence of phytochemicals

The crude aqueous, ethanolic, methanolic and chloroform extracts of *Murraya koenigii* leaves were tested for the presence of Phenolics, Flavonoids, Alkaloids, Cardiac glycosides, Anthraquinones, Terpenoids, Coumarins and Saponins. The qualitative results are expressed as (+) for the presence and (−) for the absence of phytochemicals.

*2.5.1. Test for phenols.*Assessment of phenol was determined following the method described by Harborne (1998). Briefly, 20 ml of distilled water was added to 10 mg of each extract of *Telfairia occidentalis* and 10% ferric chloride was added to each. The confirmation sign of phenols presence was formation of green or blue color.

Alkaline test for flavonoids

To 0.5 ml of the test solution, a few drops of concentrated sodium hydroxide solution were added. The formation of an intense yellow color, which turned to colorless on the addition of a few drops of dilute acid indicated the presence of flavonoids (De *et al*., 2010).

Tests for alkaloids (Mayer's test)

To 0.5 ml of each of the extracts, 1.0 ml of Mayer's reagent (potassium mercuric iodide solution) was added. A cream-colored precipitate indicated the presence of alkaloids (Harborne, 1998).

Tests for cardiac glycosides (Keller-Killani test)

Glacial acetic acid (0.4 ml) containing a trace amount of ferric chloride was added to 0.5 ml of the sample extract. Concentrated sulphuric acid (0.5 ml) was carefully added by the side of the test tube. The blue color in the acetic acid layer indicated the presence of cardiac glycosides (De *et al*., 2010; Edeoga *et al.,* 2005).

Tests for anthraquinones (Borntrager's test)

The extract (5.0 mg) was boiled with 1.0 ml of 1.0% (v/v) sulphuric acid in a test tube for 5 min. This was filtered whilst hot. After cooling, the sample extract was shaken with 1.0 ml dichloromethane. The lower dichloromethane layer was separated and shaken with 0.5 ml of 1% (v/v) ammonia. A rose-pink to red color in the layer of ammonia indicated the presence of anthraquinones (De *et al.,* 2010).

Tests for terpenoids (Salkowski test)

The crude extract (about 100 mg) was separately shaken with chloroform (2 mL) followed by the addition of concentrated H2SO4 (2 mL) along the side of the test tube, a reddish brown coloration of the interface indicates the presence of terpenoids (Ayoola *et al.,* 2008).

Test for coumarins

10 mg of each extract of *Murraya koenigii* was reacted with 10 ml of 10% sodium hydroxide. Formation of yellow colour in test sample was an indication of the presence of coumarins (Harborne, 1998).

Test for Saponins

Each of plant extracts (0.5 g) was separately shaken with distilled water (10 mL) in a test tube. The formation of frothing, which persists on warming in a water bath for 5 min, shows the presence of saponins (Banso and Adeyemo, 2006).

2.6. Determination of Antioxidant Activity using DPPH (2,2-diphenyl-1-picrylhydrazyl).The antioxidant activity of the *Telfairia occidentalis* extracts was determined using DPPH-free radical scavenging assay described by Mahdi-Pour *et al.* (2012) with slight modifications. The extract was serially diluted to concentrations of 25, 50, 100, 200, and 500 μg/mL. One mL of each dilution was mixed with 1mL of DPPH solution (0.004% in ethanol) and incubated at 37°C for 30 min. The absorbance of mixture was then measured at 517nm using a spectrophotometer. The DPPH scavenging activity was calculated as follows:

$$\text{DPPH scavenging activity } (\%) = \frac{[(\text{Acontrol - Atest})]}{\text{Acontrol}} \times 100 \quad \ldots (2)$$

Where A control is the absorbance of the negative control (DPPH solution without any sample) and A test is the absorbance of the test sample (DPPH solution plus the sample). Ascorbic acid was used as a positive control.

Total phenolic content (TPC)

Total phenolic content was analyzed using the Folin–Ciocalteu colorimetric method (Velioglu *et al.*, 1998; Cai *et al.,* 2004; Chlopicka *et al*., 2012) with some modifications. An aliquot of 0.3 mL of each extract was mixed with Folin–Ciocalteu phenol reagent (2.25 mL). After 5 min, 6% sodium carbonate (2.25 mL) was added and the mixture was allowed to stand at room temperature for 90 min. The absorbance of the mixture was measured

at 725 nm. Standard calibration curve for gallic acid in the range of 0–200 µg/mL was prepared in the same manner and results were expressed as mg gallic acid equivalent (GAE) per gram of extract.

2.8. Total flavonoid content (TFC)

Total flavonoid content was determined using the aluminum colorimetric method (Chang *et al.,* 2002; Stankovic, 2011) with some modifications using quercetin as the standard. A calibration curve of quercetin was prepared in the range of 0–200 µg/ mL. Briefly, each extract (0.5 mL) and standard (0.5 mL) were placed in different test tubes and to each 10% aluminum chloride (0.1 mL), 1 M potassium acetate (0.1 mL), 80% methanol (1.5 mL) and distilled water (2.8 mL) were added and mixed. A blank was prepared in the same manner where 0.5 mL of distilled water was used instead of the sample or standard, and the amount of aluminum chloride was also replaced by distilled water. All tubes were incubated at room temperature for 30 min. The absorbance was taken at 415 nm. The concentration of flavonoid was expressed as mg quercetin equivalent (QE) per gram of extract.

Statistical Analysis

All analyses were done at least in triplicate, and these values were then showed as mean values along with their standard derivations (±SD). Minitab software was used to analyze data. Statistical comparisons were carried out by analysis of variance (ANOVA) Tukey's multiple comparison test, and p values < 0.05 were considered as significant.

RESULTS

Effects of Different Solvents on Extraction Yield

Water and organic solvents (methanol, ethanol and chloroform) were studied for their effects on the extraction yield of *Murraya koenigii* leaves. Results showed a significant difference in the extraction yield using different solvents. Among solvents tested, methanol resulted in the highest extraction yield (5.70%), followed by distilled water (4.08%), ethanol(3.58%) and chloroform had the least percentage yield (1.27%) (Table 1), indicating that the extraction efficiency favors the highly polar solvents. This highlights thatmethanol is efficient in extracting phytochemicals from the *Murraya koenigii* leaves more than other extractionsolvents.

Phytochemical screening results

Preliminary phytochemical screening results as shown in Table 2, showed that all the extracts of the different solvents contained Phenolics, Flavonoids, Alkaloids, Cardiac glycosides, Anthraquinones, Terpenoids,Coumarins and Saponins, except the chloroform extract which showed the negative result for the presence of Coumarins and Saponins which may be due to improper solubility.

Impact of Extraction Solvents on Antioxidant activity of *Murraya koenigii* leaves extracts

In order to determine the influence of different solvents on the antioxidant capacity of crude extracts of *Murraya koenigii* leaves, *in vitro* antioxidant scavenging activity using 2, 2-diphenyl 1-picrylhydrazyl (DPPH) and ascorbic as standard were measured. The results indicated that the used solvents significantly affected the antioxidant capacity of *Murraya koenigii* leaves($p < 0.05$; Table 3). As illustrated in Table 3, different extracts possessed varying free radical scavenging activities. Among the extracts tested, methanolic extract was the most potent extract with antioxidant radical scavenging activity of 93±0.65%, followed by ethanol 81±0.13%, chloroform 73±0.22%, Ascorbic acid 66±0.05%and then distilled water 56 ±0.14% which was significantly lower than all the extracts in terms of the % DPPH which was found to be concentration dependent. The % DPPH radical scavenging activity is in increasing order with the corresponding solvents used: methanol>ethanol>chloroform> distilled water (Table 3). All the extracts except distilled water had significantly higher % DPPH radical scavenging activity than ascorbic acid.

Effects of Solvents on Total Flavonoid Content

The influence of tested solvents on crude extracts of in *Murraya koenigii* leavesis depicted in Table 3. A significant difference in the content of flavonoids in the *Murraya koenigii* leaves extracts was achieved in the presentstudy ($p < 0.05$; Table 3). The results showed that methanol exhibited the optimal solvent to extract the bioactive components from *Murraya koenigii* leaves since it has the highest content of flavonoids (15.55±0.15mg QE/g DW) of the extract, followed by ethanol (14.77± 0.08 mg QE/g DW), chloroform (14.74± 0.06 mg QE/g DW) and distilled water (14.71± 0.05mg QE/g DW) of extract, respectively.

Effects of Solvents on Total Phenolics Content

The influence of tested solvents on crude extracts of in *Murraya koenigii* leaves is depicted in Table 3. A significant difference in the content of phenolics in the *Murraya koenigii* leaves extracts was achieved in the presentstudy ($p < 0.05$; Table 3). The results showed that methanol exhibited the optimal solvent to extract the bioactive components from *Murraya koenigii* leaves since it has the highest content of phenolics (27.2±0.16 mg GAE/g DW), followed by distilled water (13.54± 0.01 mg GAE/g DW), then ethanol (11.19± 0.02 mg GAE/g DW) and chloroform had the least (8.87± 0.07 mg GAE/g DW) (Table 3).

The effect of different solvents on chemical components

Table 1: Percentage yield of the extracts made from *Murraya koenigii* leaves using different extraction solvents

Solvents	Percentage yield (%)
Chloroform	1.27
Distilled water	4.08
Ethanol	3.58
Methanol	5.70

as functional foods to promote human health and treat numerous ailments. In the present study, *Murraya koenigii* leaf was used as a natural source of secondary metabolite compounds such as phenolics and flavonoids. To obtain bioactive compounds from the plant, there are several steps comprising grinding, milling, homogenization, and extraction (Do *et al.,* 2014). Among these steps, extraction is the important step to recover and isolate bioactive compounds from the materials. The present study was conducted with an objective to identify

Table 2: Results for the phytochemical screening in different extraction solvents from *Murraya koenigii* leaves.

Phytochemicals	Solvents			
	Chloroform	Distilled water	Ethanol	Methanol
Phenolics	+	+	+	+
Flavonoids	+	+	+	+
Alkaloids	+	+	+	+
Cardiac glycosides	+	+	+	+
Anthraquinones	+	+	+	+
Terpenoids	+	+	+	+
Coumarins	–	+	+	+
Saponins	–	+	+	+

"+" = present, "–" = Absent

Table 3: Effect of different solvents on phenolic, flavonoid, and radical scavenging activity (%DPPH) of *Murraya koenigii* leaves.

Extraction solvent	Phenolics (mg GAE/g DW)	Flavonoids (mg QE/g DW)	DPPH (%)
Chloroform	8.87± 0.07[d]	14.74± 0.06[bc]	73±0.22[c]
Distilled water	13.54± 0.01[b]	14.71± 0.05[c]	56 ±0.14[d]
Ethanol	11.19± 0.02[c]	14.77± 0.08[bc]	81±0.13[b]
Methanol	27.2±0.16[a]	15.55±0.15[a]	93±0.65[a]

All values are the mean ± SD (*n*=3). Means within a column with different letters significantly differ by Tukey's test at $p < 0.05$.

of *Murraya koenigii* leaves was also analyzed by ANOVA. The results showed that methanol exhibited the optimal solvent to extract the bioactive components from *Murraya koenigii* leaves ($p < 0.05$) since the highest content of phenolics (27.2±0.16 mg GAE/g DW), flavonoids (15.55±0.15 mg QE/g DW) and % radical scavenging activity (93±0.65%) were obtained by using this solvent. Therefore, this highlights the efficiency of methanol over the other extraction solvents for extracting phytochemicals from the *Murraya koenigii* leaves (Table 3).

DISCUSSION

*Murraya koenigii*is a renowned medicinal plant known to have health benefits against various diseases. These health benefits are mainly due to the presence of many bioactive phytochemicals in various parts of this plant (Balakrishnan *et al.,* 2020). There is increasingly considerable attention on the use of bioactive compounds from natural sources

the best extraction solvent, which can be used to extract the maximum amount of the phytochemicals from the dried *Murraya koenigii* leaves.

Extraction efficiency is strongly affected by the extraction method, temperature, extraction time, the composition of phytochemicals, and the solvent used (Turkmen *et al.,* 2006; McDonald *et al.,* 2001; Ngo *et al.,* 2017). As stated by these authors' results, under the same extraction conditions, solvent is recognized as one of the most important parameters. The present study used distilled water and organic solvents viz. (methanol, ethanol and chloroform) to extract bioactive compounds from *Murraya koenigii* leaves. Results showed that different solvents resulted in various extraction yields. This is because differences in the polarity of the extraction solvents could cause a wide variation in the level of bioactive compounds in the extract. A higher extraction yield was observed in methanolic extract, distilled water extract, and ethanolic extract compared to chloroform, indicating that the

extraction efficiency favors the highly polar solvents. This result is consistent with the extraction yield of *Limophila aromatic* (Do *et al.,* 2014),*Severinia buxifolia* (Truong *et al.,* 2019)*, Datura metel* (Dhawan and Gupta, 2017)and some other medicinal plants (Kuppusamy *et al.,* 2015). This could be because the plant material has high levels of polar compounds that are soluble in solvents with high polarity such as water, methanol, and ethanol.

Qualitative biochemical estimations were conducted to detect the presence of different phytochemicals in the dried *Murraya koenigii* leaves' extracts obtained by using different solvents i.e., methanol, ethanol, chloroform and distilled water. Our results highlights that all the extracts formed by using different solvents from *Murraya koenigii* leaves contains phytochemicals like Phenolics, Flavonoids, Alkaloids, Cardiac glycosides, Anthraquinones, Terpenoids,Coumarins and Saponins. However, Coumarins and Saponins were found to be absent in the chloroform extract. It may be due to poor solubility of these phytochemicals in chloroform (Table 2). This shows the inefficiency of chloroform to be used as phytochemical extraction solvent for *Murraya koenigii* leaves.

In order to better understand the solvents effect on extraction yield, further analysis was performed to measure the content of bioactive compounds in the extract. In accordance with the extraction yields, the content of bioactive compounds (phenolics and flavonoids) varied amongst the extracts. The highest levels of phenolics and flavonoids were observed in methanolic extracts, thus resulting in the highest extraction yield of methanolic extract. This can be attributable to higher solubility of these compounds in methanol than the other solvents tested (Do *et al.,* 2014). All together, these findings suggest that methanol is the best solvent for extracting bioactive compounds from *Murraya koenigii* leaves.

Extraction solvents have an effect on the extraction yield and the content of bioactive compounds, thus significantly affecting the biological activity of the extract (Turkmen *et al.,* 2006; McDonald *et al.,* 2001; Ngo *et al.,* 2017). In this study, the extracts obtained from different solvents were studied for their antioxidant activity by using DPPH scavenging activity assays. Among the extracts tested, the methanolic extract was the most potent in terms of % DPPH radical scavenging activity. This could be because this extract contained the highest level of phenolic and flavonoid compounds (Ruiz-Ruiz *et al.,* 2017; Kuppusamy *et al.,* 2015; Chao *et al.,* 2014). These compounds possess powerful antioxidant activity and consequently protect the human body against oxidative damage through scavenging diverse reactive oxygen species, including hypochlorous acid, superoxide anions, hydroxyl radicals, peroxyl radicals and peroxynitrite (Chao *et al.,* 2014). Remarkably, methanolic extract of *Murraya koenigii* leaves exhibited a higher % DPPH scavenging activity than that of ascorbic acid. These findings suggest that the methanolic extract of *Murraya koenigii* leaves is a potential antioxidant agent for further drug development.

CONCLUSION

The present study reports the extraction of *Murraya koenigii* leaves using different solvents. Among the solventstested, methanol was the best solvent for extracting bioactive compounds from *Murraya koenigii* leaves since it resulted in thehighest extraction yield and highest content of phenolics and flavonoids. The antioxidant activity of the extracts wasalso investigated. Compared with other extracts, methanolic extract of *Murraya koenigii* leaves exhibited the highest antioxidant activity. These results suggest that methanol is the best solvent for bioactive compounds extraction from *Murraya koenigii* leaves and that methanolic extract is a promising antioxidant for the nutraceutical and pharmaceutical industries. To best of our knowledge this is the first report that directly compares these four extraction solvents and our results clearly demonstrates that methanol is the best extraction solvent for the extraction of various phytochemicals from *Murraya koenigii* leaves. This can be explored further.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest.

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