



Original Article

Ethnomedicinal survey of traditional antidiabetic plants in Baturraden and Sumbang

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ABSTRACT

Background: The scientific-based jamu development program enables the development of medicinal plants in the traditional medicine system that eventually can be used in the formal healthcare system. Baturraden and Sumbang are considered as areas with abundant plant biodiversity in Java, where the local community has used those plants for medicinal purposes.

Objective: This study is conducted to qualitative and quantitatively record and conserve the knowledge of the Baturraden and Sumbang community on the utilization of plants for treating diabetes mellitus.

Method: The data of the plant's local names, plant organs, methods of preparation, and routes of administration of the herbal preparations used for treating diabetes mellitus were collected through semi-structured interviews with 97 informants. The species use-value (SUV), the relative frequency of citation (RFC), and fidelity level (FL) of each species were calculated accordingly to determine their relative importance and value to the local community.

Result: There were 11 plant species from 10 families mentioned. The most commonly used plant organ, preparation method, and administration route were leaves, decoction, and oral, respectively. The most important and valuable plants were including *Piper ornatum* (SUV = 0.19, RFC = 0.13, FL = 23.09%) and *Andrographis paniculata* (SUV = 0.09, RFC = 0.07, FL = 42.86%).

Conclusion: As the most critical antidiabetic plant in the studied area, the decoction or infusion of *Piper ornatum* leaves is taken orally 1-2 times a day. However, there are no reports on its anti-diabetic-related activities available to date. In contrast, the uses of *Andrographis paniculata* as the antidiabetic agent has been widely proven. Baturraden and Sumbang people orally consumed the decoction of this plant's leaves once a day for the said purpose.

INTRODUCTION

The use of *jamu*, Indonesian traditional medicine, is still considered necessary in Indonesia, particularly in rural areas. The self-made herbal preparations used as *jamu* from plant materials available around the neighborhood are commonly practiced.^{1,2} The use of herbal medicines, concurrently or alternately with conventional ones, is frequently found, including among diabetic patients in Indonesia.³ More than 10% of the respondents of a national population survey mentioned the use of both traditional and conventional medicines for the treatment of their diabetes mellitus.⁴ In Indonesia, diabetes mellitus is the significant three non-communicable diseases causing death.^{5,6} The prevalence of diabetes in adults, according

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to the consensus of The Indonesian Society of Endocrinology, is 10.9%.⁷ However, very little work covering the traditional utilization of medicinal plants for the treatment of this disorder has been done in Indonesia. There are only two studies available, and they were conducted in Subulussalam (Aceh) and Simalungun (North Sumatra).^{8,9}

Baturraden and Sumbang are located in the slope of Gunung Slamet, one of the last-remained affluent biodiversity areas in Java. It is crucial to study the utilization of those abundant plants for medicinal purposes by the local people, for their knowledge can be used as the basis for the further development of traditional medicine. The first stage of scientific-based *jamu* development (*saintifikasi*

jamu in *Bahasa Indonesia*) program is the ethnopharmacological study to register the traditional uses of medicinal plants nationwide.¹⁰ Previously, there were two ethnomedicinal surveys conducted in Baturraden; the first enlisted the medicinal plants for treating diarrhea while the later reported the therapeutic utilization of plants of Rosidae subclass.^{11,12} However, both studies were qualitative ones; they did not say the importance of the individual plants cited by the informants. Also, no ethnopharmacological studies cover Sumbang to date.

To the best of our knowledge, this is the first ethnopharmacological study covering plants for the treatment of diabetes mellitus in the studied area with qualitative and quantitative approaches. This study aimed to explore the utilization of medicinal plants in their surroundings for the treatment of diabetes mellitus. The species of plants, plant organs, preparation methods, routes of administration, and the dose of those herbal preparations were qualitatively described. The importance of each plant was quantitatively determined by using species-use value (SUV), the relative frequency of citation (RFC), and fidelity level (FL) as the indices. Furthermore, the recent data on traditional uses and antidiabetic-related activities of cited plants were also discussed in this study.

METHOD

The Location of Study

Baturraden and Sumbang are two sub-districts of Banyumas located between 7°14'-7°40' north latitude and 109°12'-109°30' east longitude. They cover an area of 45.53 and 53.42 km², respectively. The area is bordered by Tegal and Pemalang Regencies in the north, Purbalingga Regency in the east, North Purwokerto, and Kembaran Sub-districts in the south, and Kedungbanteng sub-district in the west (Figure 1). As of 2018, the population of Baturraden and Sumbang was 52,895 and 84,049, respectively.¹³ Both sub-districts were not considered as the crop-producing areas, but corn plantations with different types of weed were commonly found in the southern part of Sumbang. Besides, the high biodiversity of the tree was reported in the Gunung Slamet protected forest located in the northernmost part of Baturraden.¹⁴⁻¹⁶

Informants and Ethnopharmacological Data Collection

The survey was conducted from January-March 2017. Before data collection, the protocol of this study has granted ethical approval from the Ethical Commission of Faculty of Medicine and Health Sciences, Universitas Jendral Soedirman (Ref: 187/KEPK/XI/2016). The minimum number of informants for this study was determined using a survey sample calculation formula.¹⁷ There were 97 informants interviewed, and they were sampled from all villages in Baturraden and Sumbang, in which their number

was proportional to the population of the respective village. The inclusion criteria for the selection of informants were including reside in the studied area, have the knowledge and experience of the use of the plants for treating ailments/diseases for themselves or other people, literate, and is aged of 17 years old or older. The data were collected through a semi-structured interview after the written informed consent was obtained from the informants. It addressed demographic (ethnicity, gender, age, and education level) and traditional utilization of medicinal plants (local name, plant organs used, preparation method, administration route, and dose) data. The informants were asked to free list all plants they knew, but only those used for treating diabetes mellitus were reported in this study.

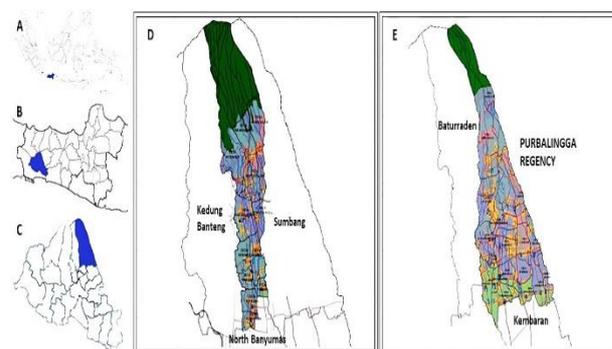


Figure 1. Maps show the studied area; (A) Indonesia, (B) Central Java Province, (C) Banyumas Regency, (D) Baturraden, and (E) Sumbang

Medicinal Plants Collection and Identification

Plants mentioned during interviews were photographed and collected for preparing voucher specimens following the standard method of herbarium preparation.¹⁸ They were identified with the help of standard literature (Flora of Java as well as the online version of Flora Malesiana (<https://floramalesiana.org>) and Flora of China (<http://www.efloras.org>)). They were deposited at the Faculty of Pharmacy, Universitas Muhammadiyah Purwokerto. The names of the plant were written according to their nomenclature in The Plant List (<http://www.theplantlist.org>).

Data Analysis

The quantitative indices used are including SUV, RFC, and FL.^{19,20} SUV represents the relative importance of a given species known locally and is calculated using a formula as follow:

$$SUV = \sum \frac{U_i}{N} \quad (1)$$

Where U_i is the number of uses of a given plant species cited by informants, and N is the total number of informants. On the other hand, RFC indicates the local value of every plant species and is calculated using a formula:

$$RFC = \frac{FC}{N} \quad (2)$$

Where FC is the number of informants mentioning the use of a given species, and N is the total number of informants. Furthermore, FL demonstrated the local relative efficacy of a given plant species and was calculated using a formula as follow:

$$FL = \frac{Ip}{Iu} \times 100 \quad (3)$$

Where Ip is the number of informants citing the use of a given species for a particular purpose and Iu is the total number of informants mentioning any uses of that plant.

RESULTS

The Demographic Characteristics of Informants

There were a total of 97 informants interviewed, in which all self-identified as Javanese. There were more females who familiar with the use of medicinal plants compared to males. Most informants were in the age range of 50-59 years and subsequently followed by those in the group of 60-69 years old. Nearly half of the number of informants was graduated from elementary school (Table 1).

Table 1. The demographic data of informants

Characteristics	Frequency	Percentage
Javanese ethnicity	97	100%
Gender		
Male	20	20.6%
Female	77	79.4%
Age (years)		
21-29	10	10.3%
30-39	13	13.4%
40-49	15	15.5%
50-59	26	26.8%
60-69	24	24.7%
70-79	7	7.2%
80-89	1	1.0%
Education level		
No formal education	6	6.2%
Elementary school	43	44.3%
Junior high school	12	12.4%
High school	29	29.9%
University	7	7.2%

Traditional Antidiabetic Plants and Their Utilization

There were a total of 10 families utilized for treating diabetes mellitus in Baturraden and Sumbang. All families consisted of a species except Compositae, whose two cited members (Figure 2, Table 2). Leaves are the most commonly used plant organ and followed by fruits. Usually, only an organ of the plant was used, but the locals used leaves and flowers of *Catharanthus roseus* altogether for the said purpose. Those plant materials were individually used as a single plant preparation. People in the studied area most commonly used decoction to prepare them. *Piper ornatum* was used differently in Baturraden and Sumbang. It was boiled in the first-mentioned sub-district and decocted in the later. Fruits were unprocessed, both *Muntingia calabura* and *Morinda citrifolia* fruits were

Table 2. Plants used for traditional treatment of diabetes mellitus in Baturraden and Sumbang

freshly eaten. All of the herbal preparations were administered by oral route in varying doses of 1-2 times a day or as needed (Figure 3).

The Quantitative Indices Value of the Plants

The SUV of the cited plants ranged from 0.02 (*Tinospora crispa* and *Melia azedarach*) to 0.19 (*Piper ornatum*). At the same time, the RFC was also varied from 0.01 (*Melia azedarach* and *Muntingia calabura*) to 0.13 (*Piper ornatum*). Interestingly, the maximum FL of 100% was recorded for *Smalanthus sonchifolius*, *Muntingia calabura*, and *Melia azedarach*, while those of *Vernonia amygdalina*, *Morinda citrifolia*, and *Annona muricata* were not more than 20% (Table 2).



Figure 2. Traditional antidiabetic plants used by Baturraden and Sumbang people

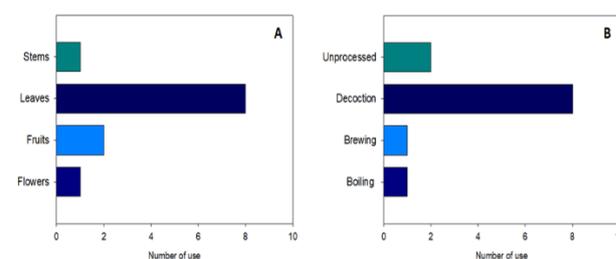


Figure 3. The utilization of traditional antidiabetic plants; (A) by plant organs and (B) by the preparation method

DISCUSSION

The demographic characters of the informants demonstrated that the knowledge and experience of using plants for treating diabetes mellitus were common among women, elderly, and elementary school-educated population. Women were previously reported more frequently using antidiabetic plants in Fez-Meknes (Morocco).²⁰ As some medicinal plants were also foods, it explained why women who traditionally responsible for providing everyday meals also had a fundamental role in preparing homemade herbal medicines for family members.²¹ The long experience of older people seemed to support their more knowledge about medicinal plants.

Scientific name Family	Local name	SUV	RCF	FL (%)	Preparation method	Route	Dose
<i>Andrographis paniculata</i> (Burm.f.) Nees Acanthaceae	Sambiloto	0.09	0.07	42.86	3-7 leaves are decocted in water	Oral	Once a day
<i>Annona muricata</i> L. Annonaceae	Sirsak	0.07	0.07	14.29	3-7 leaves are decocted in water	Oral	Twice a day
<i>Anredera cordifolia</i> (Ten.) Steenis Basellaceae	Binahong	0.08	0.07	28.57	2-3 leaves are brewed in a glass of water	Oral	Twice a day
<i>Catharanthus roseus</i> (L.) G.Don. Apocynaceae	Tapak dara	0.05	0.03	33.33	Leaves and flowers are decocted in water	Oral	Twice a day
<i>Melia azedarach</i> L. Meliaceae	Mindi	0.02	0.01	100	A half of handful of leaves are decocted in water	Oral	Twice a day
<i>Morinda citrifolia</i> L. Rubiaceae	Mengkudu	0.04	0.05	20	1-3 fruits are freshly eaten	Oral	As needed
<i>Muntingia calabura</i> L. Muntingiaceae	Kersen	0.04	0.01	100	Ripen fruits are freshly eaten	Oral	As needed
<i>Piper ornatum</i> N.E.Br. Piperaceae	Sirih merah	0.19	0.13	23.08	2-3 leaves are infused in water, or seven leaves are decocted in water	Oral	1-2 times a day
<i>Smallanthus sonchifolius</i> (Poepp.) H.Rob. Compositae	Insulin	0.04	0.02	100	5-10 leaves are decocted in water	Oral	Twice a day
<i>Tinospora crispa</i> (L.) Hook. f. & Thomson Menispermaceae	Bratawali	0.02	0.02	66.67	Dried stems are decocted in water	Oral	Twice a day
<i>Vernonia amygdalina</i> Delile Compositae	Asia afrika	0.07	0.05	20	3-5 leaves are decocted in water	Oral	Twice a day

Our result was similar to data from Pakhtunkhwa (Pakistan), in which the traditional healers are prescribing herbal preparations for treating diabetes mellitus were mostly elderly.²² Our data suggested that the younger and higher educated generations in Northern Banyumas had less knowledge and experience in using plants for traditional treatment of diabetes mellitus.

Compositae is the family in Angiospermae with the most significant number of members and abundantly found in the tropical areas.²³ It may explain the use of both *Smallanthus sonchifolius* and *Vernonia amygdalina* to cure diabetes mellitus in the studied area. The utilization of other Compositae plants for the purposes above, for example, *Taraxacum officinale* (L.) Weber ex F.H.Wigg. has been reported in Simalungun (North Sumatera).⁸ Furthermore, five plant species of Compositae were also popularly used for treating diabetes mellitus in Thailand.²⁴ The widespread use of leaves for treatment of diabetes mellitus has also been reported in Pakhtunkhwa (Pakistan) and Rabat (Morocco).^{24,25} Also, leaves were identified as the most commonly used organ of antidiabetic plants elsewhere in Indonesia.²⁶

As commonly practiced nationwide, people of Baturraden and Sumbang also recognized three methods in preparing their water extract of herbal preparations, and they were tea, infusion, and decoction. In tea, plant materials were

poured with boiling water and brewed to room temperature. In infusion and decoction, plant materials were slowly heated in water until steam was obtained or reduced to a half/ a third of the original volume, respectively. The decoction method is accessible for the common belief that it can optimally extract the phytochemicals.²⁷ Besides, recent data demonstrated that *Rosmarinus officinalis* extract derived from the decoction process generated the highest concentration of phenolic compounds and subsequently possessed the highest antioxidant activity compared to those derived from infusion and methanol extraction.²⁸

While the SUV of a given plant represents its relative importance, RCF indicates its relative value to the local community. As the most essential and valuable plants, *Piper ornatum*, *Andrographis paniculata*, *Anredera cordifolia*, *Annona muricata*, and *Vernonia amygdalina* were not only used for treating diabetes mellitus but also indicated for other diseases. Among those plants, *Andrographis paniculata* is the most well-characterized one, with andrographolide and other diterpene lactones as the bioactive compounds.²⁹ On the other hand, plants with lower SUV, including *Melia azedarach* and *Tinospora crispa* were considered having the significant uses for treating diabetes mellitus by the local. As for *Tinospora crispa*, borapetosides and the related clerodane diterpenoids are considered as the anti-hyperglycemic compounds.^{30,31} The high FL of *Smallanthus sonchifolius*, *Muntingia calabura*, and

Melia azedarach refers to the same way of using those plants and, hence, is related to their relatively low SUV.

Interestingly, the data on traditional uses and pharmacological studies of plants used for treating diabetes mellitus in Baturraden and Sumbang are widely varied. Some plants are well studied, while others are understudied. The ethnomedicinal uses of *Andrographis paniculata* for diabetes mellitus are reported in Morowali (Central Sulawesi), Rokan Hulu (Riau), Bogor, and Sigi (Central Sulawesi).³²⁻³⁵ This traditional use has been evaluated in various models, and the antidiabetic-related activities of this plant are confirmed.

The water, hydroethanolic, and methanolic extract of this plant were found to be useful for restoring on obese-diabetic rats' disturbed metabolic profile back towards normal conditions, attenuating cognitive deficits, reducing acetylcholinesterase activity and oxidative stress, improving diabetic hyperglycemia and insulin deficiency, as well as showing immunostimulant, cerebroprotective and nootropic activities in rats.³⁶⁻³⁸ Also, the purified extract of *Andrographis paniculata* reduced the blood sugar level in hyperglycemic rats induced by a high-fructose-fat diet. At the same time, its chloroform fraction ameliorated the lipid profile in those diabetic mice and increased in vitro insulin.^{39,40} In a clinical study involving 20 patients with type 2 diabetes, *Andrographis paniculata* caused no significant adverse effects while decreased HbA1c and fasting insulin levels in those patients.⁴¹

Annona muricata is also used for the said purpose in Subulussalam and Bogor.^{9,34} This use has been confirmed in diabetic rats, in which its extract was capable of improving the behavioral alterations and protecting testis from oxidative stress.⁴² Furthermore, ethyl acetate and n-butanol fractions of ethanolic extract of its leaves showed α -amylase, α -glucosidase, and lipase inhibitory activities.⁴³ The α -amylase inhibitory activity was also shown by this plant's fruit-pulp and root-bark methanolic extracts.⁴⁴

Anredera cordifolia is known as a traditional diabetes mellitus remedy in Sigi Biromaru (Central Sulawesi).⁴⁵ Meanwhile, the ethanolic extract of this plant showed α -glucosidase inhibitory activity, and the subsequently isolated flavonoid was capable of lowering the blood glucose level in diabetic mice.⁴⁶ Besides, the gel containing 10% ethanolic extract of this plant's leaves was found to be useful for diabetic ulcer wound healing in rats.⁴⁷

The traditional antidiabetic activity of *Catharanthus roseus* is reported in Subulussalam, Simalungun, Rokan Hulu, Malang (East Java), and Parigi Moutong (Central Sulawesi).^{8,9,33,48,49} Previous studies supported this traditional use; for example, the juice of *Catharanthus roseus* fresh leaves was capable of reducing the blood glucose level in diabetic rats.⁵⁰ Furthermore, its phenolic fraction that was rich with gallic acid and chlorogenic acid demonstrated a

reduction in blood glucose level in mice as well as stimulation in insulin secretion and expression in RINm5F cell line.⁵¹

There was no other report on the traditional use of *Melia azedarach* for treating diabetes mellitus in Indonesia to date. However, its antidiabetic-related activity has been reported in rats, in which its leaves extract showed blood glucose level decreasing, peripheral glucose uptake improvement, gastric emptying rate reduction, and insulin demand lowering effects.⁵² Furthermore, these anti-hyperglycemic effects were also demonstrated by *Melia azedarach* collected in India.⁵³

Morinda citrifolia is a popular traditional antidiabetic plant from Southeast Aceh and Subulussalam, Simalungun, Bogor, and Malang.^{8,9,34,48,54,55} The hypoglycemic activity of this plant has been confirmed in the high-fat diet rats, in which it was also capable of improving glucose metabolism.⁵⁶ Also, its leaves ethanolic extract significantly improved the metabolic perturbations in high-fat diet rats.⁵⁷ Furthermore, the juice of *Morinda citrifolia* fruits significantly reduced the morning blood glucose and HbA1c levels in patients with type 2 diabetes mellitus.⁵⁸

Traditional use of *Muntingia calabura* for diabetic medication is reported in Subulussalam, Karawang (West Java), and Bau-bau (Southeast Sulawesi).^{9,59,60} The previous study demonstrated that the stem bark extract of this plant was useful for lowering the uric acid level and maintaining the healthy structure of renal proximal tubular cells in diabetic rats.⁶¹ Besides, the antidiabetic activity of water extract of this plant was mediated by decreased blood glucose level, regenerated pancreatic β - cells, and improved insulin sensitivity.⁶²

Piper ornatum is also commonly used for treating diabetes mellitus in Donggala (Central Sulawesi), Bau-bau, and Bogor.^{34,60,63} However, there is no report on the in-vivo and in-vitro efficacies of this plant as the antidiabetic agent to date. On the other hand, ethanolic extract of the leaves of this plant was proven to be non-hepatotoxic to diabetic rats, as it did not alter their alanine transaminase (ALT) dan aspartate transaminase (AST) levels.⁶⁴

Smilax sonchifolius is also understudied in Indonesia, as there is no ethnomedicinal study reporting its use for treating diabetes. However, antidiabetic-related activities of this plant in the animal models have been widely described, particularly in South America. The root flours were useful for improving lipid profiles, as well as reducing oxidative- and increasing antioxidative enzymes level in diabetic rats.⁶⁵ Furthermore, the hydroethanolic extract of this plant leaves also demonstrated an anti-hyperglycemic activity that was mediated by improving glucoregulation and ameliorating oxidative stress and inflammation mechanism in rats.⁶⁶

Tinospora crispera is commonly used for the treatment of diabetes mellitus in Poso (Central Sulawesi), Bau-bau, and Simalungun.^{8,60,67,68} Interestingly, the hydro-methanolic extract of this plant showed a potent α -glucosidase and α -amylase inhibitory activity.⁶⁹ However, the hypoglycemic effect of *Tinospora crispera* was not confirmed in human. A clinical study on ten healthy subjects and ten diabetic participants showed that its ethanolic extract did not affect their serum glucose and insulin levels.⁷⁰

The record on the use of *Vernonia amygdalina* as a traditional antidiabetic treatment is reported in Subulussalam and East Kutai (East Kalimantan).^{9,71} This use supported data from a preclinical study in diabetic rats, in which this plant extract suppressed their hepatic gluconeogenesis.⁷² Also, it was capable of stimulating glucose uptake in rat brain as well as showing neuroprotective effects.⁷³

CONCLUSIONS AND RECOMMENDATION

There were 11 plants traditionally used for treating diabetes mellitus in Baturraden and Sumbang. Leaves and decoction were cited to be the most commonly employed plant organ and preparation method, respectively. All of those plant materials were used as a single plant herbal preparation and administered by the oral route. The most essential and valuable antidiabetic plants in the studied area included *Piper ornatum*, *Andrographis paniculata*, and *Anredera cordifolia*.

It is recommended to use data collected in this study as the rationale for the selection of medicinal plants for further development into standardized herbal medicines indicated for diabetes mellitus or inclusion into the scientific-based *jamu* development program. As *Piper ornatum* is the most valuable plant in the studied area but is still understudied, it should be evaluated for its in-vivo and in-vitro antidiabetic-related activities. The preparations of *Annona muricata* and *Andrographis paniculata*, whose antidiabetic properties have been well characterized, should be standardized to assure their efficacy and safety of use.

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