"*Mangidy*": Malagasy folk beverages sold in Madagascar's marketplaces

Nivo H. Rakotoarivelo, Tabita N. Randrianarivony, Fortunat Rakotoarivony, Armand Randrianasolo

Research

Abstract

Background: "Mangidy" is a common Malagasy infusion or decoction meant to heal or to prevent many different ailments. It is generally sold by ambulant merchants in different places of large cities' markets, especially in Antananarivo, the capital city of Madagascar. However, despite its popularity in Madagascar, there has been virtually no scientific documentation of its constituent plants and the conditions for which it is prescribed.

Methods: The present study is aimed to conduct a survey in Antananarivo markets to identify the different plant species used to make "mangidy" and their medical properties. One hundred and five informants between the ages of 17 and 75 years old were interviewed using semi-structured interviews.

Results and Discussion: The results indicated 24 plant species that have been used to make "mangidy". *Cedrelopsis grevei* Baill., *Cereus triangularis* (L.) Haw., *Paramollugo nudicaulis* (Lam.) Thulin and *Cinnamomum camphora* (L.) J. Presl were frequently cited. Usually, two to five plant species were used together as a remedy for a wide range of diseases such as asthenia, stomach-ache, hyperglycemia, and erectile dysfunction. However, consumption of "mangidy" is currently medically questionable as the dosage is not well defined and the side effects are still undocumented.

Conclusions: This study highlights the importance of plants in making "mangidy" beverages and how important they are for some Malagasy people. However, more research is needed to investigate the identity, safety, and efficacy of the compounds contained in these plants so they can be used appropriately and safely.

Keywords: Mangidy, herbal tea, ethnobotany, Antananarivo, Madagascar.

Famintinana

Tontolon-kevitra: Ny "mangidy" dia anarana iantsoan'ny Malagasy ireo zava-pisotro manana tsiro mangidy na mafaitra izay heverina fa mahasalama na mahasitrana aretina maro. Hita amidin'ny olona amin'ny tavoahangy sy siny eran'ireo tsena amin'ny tanàn-dehibe maro eto Madagasikara izy io, indrindra fa eto Antananarivo renivohitra. Kanefa, na dia eo aza ny lazany sy ny fahafantaran'ny olona maro azy, dia tsy mbola misy firy ny antontam-pikarohana nivoaka milaza ireo singa raketiny sy ny fomba fampiasana azy.

Fomba fiasa: Ity fanadihadiana notanterahina teny amin'ny tsenan'Antananarivo ity dia natao mba hamantarana ireo karazan-javamaniry, ampiasaina hahazoana ireny "mangidy" ireny sy ireo karazan'aretina voaaro na voatsabo noho ny fisotroana azy. Dimy amby zato ireo olona nanaovana ny fanadihadiana, izay teo anelanelan'ny 17 ka hatramin'ny 75 taona.

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Vokatra: Ny fanadihadiana natao dia nahazoana karazan-javamaniry 24 ampiasaina amin'ny fanamboarana "mangidy", ka *Cedrelopsis grevei* Baill., *Cereus triangularis* (L.) Haw., *Paramollugo nudicaulis* (Lam.) Thulin ary *Cinnamomum camphora* (L.) J. Presl no voatonona matetika. Amin'ny ankapobeny, dia misy karazan-javamaniry roa ka hatramin'ny dimy no afangaro hanaovana "mangidy", izay mazàna itsaboana aretina samihafa toy ny havizanana, aretim-bavony, fiakaran'ny tahan'ny siramamy ary koa atao fanafody mampatanjaka. Na izany aza, dia mbola mampiahiahy eo amin'ny sehatry ny fitsaboana ny fisotroana azy noho ny fatra ampiasaina tsy dia voahaja loatra ary ny voka-dratsy haterany izay mbola tsy fantatra mazava.

Famaranana: Ity fanadihadiana natao ity dia manasongadina ny ilàna ny zavamaniry amin'ny fanamboarana "mangidy" sy ny maha-zava-dehibe azy ho an'ny Malagasy sasantsasany. Na izany aza, fikarohana maro no ilaina mba ahafahana mamantatra ny anarana ara-tsiantifikan'ilay zavamaniry, ny fitandremana tokony atao, ary ny herin'ny singa fototra ao anatiny mba ahafahana mampiasa azy araka ny tokony ho izy sy amim-pitandremana.

Teny fototra: Mangidy, tambavy, etnôbôtanika, Antananarivo, Madagasikara.

Background

Commonly known under the Malagasy term "mangidy", some herbal teas made from plant species are frequently sold in the markets of Antananarivo and several other cities and towns in Madagascar. The term "mangidy" (which means "bitter" in English) generally refers to bitter tasting beverages made of infused or decocted plants. Sometimes though, the term "tambavy" is used instead of "mangidy" when referring to "tisanes", a type of herbal tea mixture that generally forms the basis of much of the traditional medicine in Madagascar as well as in Mascarenes areas (Pourchez 2017). Currently, both names are used synonymously.

In Mascarenes areas, the word "tanbav" has its origin from the Malagasy word "tambavy". Both terms are used to designate a childhood illness. This illness is characterized by intestinal and digestive problems (particularly colic) and skin problems (Pourchez 2017). As reported by the same author, starting two centuries ago in Madagascar, "tambavy" still generically refers to meconium, the soft green feces of a newborn. Nowadays, it not only refers to the childhood illness, but also to the range of remedies and herbal teas ("tisanes") sold for the treatment of "tanbav" (Pourchez 2017).

However, the term "tambavy" has changed and has extended its meaning to include other herbal teas (called "mangidy" in Malagasy) generally sold by ambulant merchants in different places of larger cities' markets, especially in Antananarivo, the capital of Madagascar. "Tambavy" or "mangidy" are common drinks consumed on a daily basis by many Malagasy people, not only for a curative purpose, but to prevent many different ailments as well (Debray 1975). In the city of Antananarivo, while the two terms are both used interchangeably, the term "mangidy" is more commonly and frequently used. In this paper, because of its commonality, we use the term "mangidy" to refer to all curative and preventive medicinal herbal teas sold in water cans or plastic bottles in different market places of the city. "Mangidy" beverages are always sold in water cans with plastic bottles by peddlers.

Merchants of "mangidy" in the Antananarivo markets are mostly composed of immigrants from different regions of Madagascar (e.g. Androy, Vakinankaratra and Analamanga) or rural people living on the fringes of the capital city. Basically, these migrating people (mainly rural farmers) are looking for easy income-generating activities like selling "mangidy" to make a living in urban cities like Antananarivo. They leave their villages in hopes finding a better way of living as life in their villages has become hard due to increasing insecurity, scarcity of agricultural land parcels for farming, and the effects of climate change (e.g. long drought, multiple flooding), making it hard to survive on subsistence farming. Merchants of "mangidy" are found along the streets of market places or typically around bus stations. So far, selling "mangidy" is still a legal activity under Madagascar's laws as the Malagasy Department of Public Health has yet to issue any sort of restriction or prohibition for the sale of "mangidy'. However, these beverages are not recommended by Malagasy physicians because of their possible negative side effects. Plants used to make those herbal teas are not always well known, making medical doctors suspicious of their effectiveness as remedies. In addition, no scientific studies nor thoroughly verified information have been published about these popular herbal teas despite the efforts of some pharmacologists, medical doctors, and researchers from different Malagasy institutions, like the Institute of Public and Community Health, to determine the possible toxicity of the mixtures (Didier 2015). According to Razanadimby (2013), scientific information on the quality (biological and

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toxicological effects) and the quantity (dosages) of plants used to make “mangidy” is not sufficient to prove that the plants used in “mangidy” beverages are harmless to people’s health. To help elucidate the controversy surrounding the “mangidy” beverages, we conducted a survey on plants used to make “mangidy” in and around Antananarivo. This survey is the first attempt to document ethnobotanical information on these bitter beverages considered to be preventive and curative medicines for some diseases. There are two main objectives for this study: 1) to scientifically identify the plant species used to make “mangidy” and document illnesses they are supposed to prevent or treat, and 2) to compile information on the different mixtures of plant species in the “mangidy” beverages and present it in a form that can be useful for other researchers.

Materials and Methods

Antananarivo, the capital city of Madagascar, is a place where street trades are a common phenomenon. Street vendors can be found all along the streets, especially in market places and bus stations. Vendors can also be seen occupying sidewalks along the city roads. Street markets are places where both consumers and ambulant merchants of “mangidy” can be found socializing. Twelve places around the capital city were strategically chosen to conduct the study (Fig. 1).

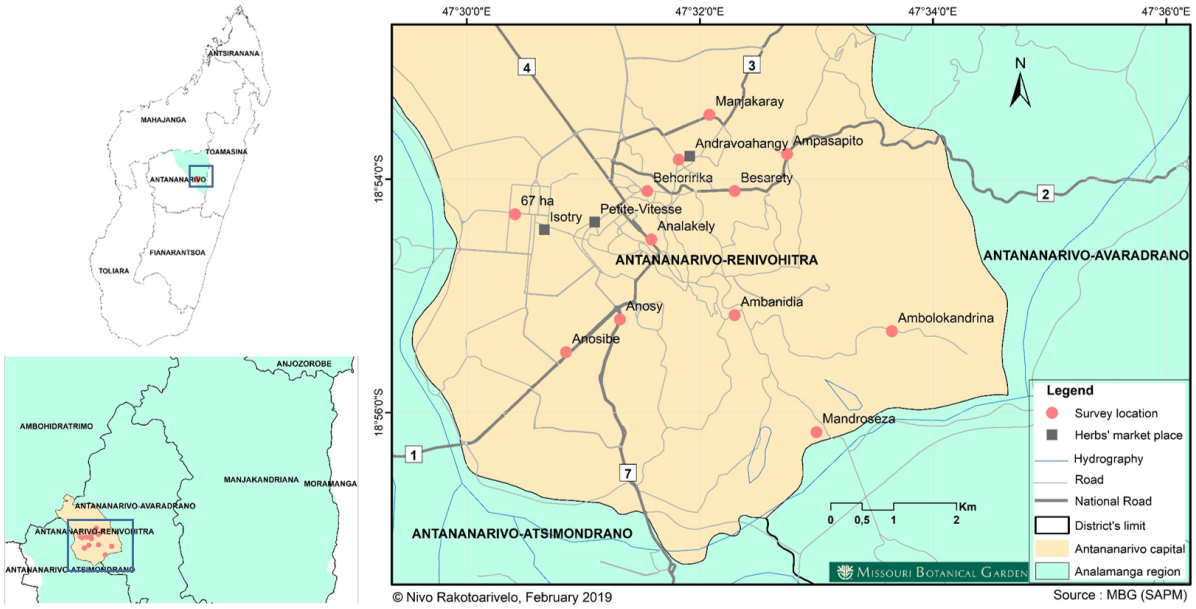

Fig. 1. Survey locations and herb’s market places in Antananarivo

The ethnobotanical surveys were conducted in the morning until noon. Semi-structured interviews (Martin 1995) were used to collect information on the plant compositions used to make “mangidy”. A questionnaire (Supplementary Material) was used as a guide during the interviews (Gerique 2006) and was specified for two types of informants: vendors and public (including consumers and non-consumers of “mangidy”). Vendors were asked regarding their knowledge on plants used to make “mangidy” beverages while consumers or non-consumers on their buying habits and/or perceptions of “mangidy” consumption. Prior informed consent was obtained orally from willing participants prior to each interview (Secretariat of the Convention on Biological Diversity 2011). Public informants were randomly selected. However, vendors encountered in the markets or streets during the visit were all interviewed. Plant vernacular names, plant uses, preparation methods and administration, and places where the vendors collect or purchase the plant material used were recorded. Medicinal purposes of each species were classified using the sub-categories defined by Cámara-Leret *et al.* (2012) for medicinal and veterinary category. Furthermore, the informants’ perception on “mangidy” consumption were also noted.

For plant identification, dried plant species were bought at the herbalists and then presented to one of the Missouri Botanical Garden’s plant specialists in Madagascar for scientific names confirmation. When possible, vouchers were collected and identified at the Madagascar national herbarium of Tsimbazaza (TAN). Previously collected vouchers were also used to confirm the identification (voucher

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numbers are given in Table 1). In addition, pertinent publications on medicinal plants, such as the one published by Randriamiharisoa *et al.* (2015), were consulted and used to elicit the identification of cited plant species without vouchers. Vernacular names were compared, then the scientific names were confirmed with the plant specialist. Free listing analysis was used to pinpoint the species and the uses frequently cited by informants (Quinlan 2005). Frequency of citation is defined as the repetition of how many times one species is mentioned by informants for a use.

Results

Generality about "mangidy" sellers and consumers

One hundred five informants, ranging from ages 17 to 75 years old, were interviewed. Of those interviewed, 32 were vendors and 73 were public (consumers or non-consumers). Only 26 of the informants were women, of which four were vendors. Most of the vendors were peddlers, except for the four women mentioned previously and two men; the six non-peddler vendors each had permanent stands and sold the herbal tea either by itself or with other products such as fruits and vegetables (Fig. 2).

Generally, selling herbal teas is seen more of as a male activity in Antananarivo since it requires constantly moving from one place to another. Sellers of "mangidy" are considered as ambulant sellers, or peddlers, as they walk more than 15 km a day to sell their products. They sell "mangidy" in two to three fixed marketplaces where they already have devoted costumers. They can move up to three times a day between those different areas to earn more money and they can sell up to four sets of herbal tea a day. One set of the herbal tea usually comprises about eight plastic bottles (1.5 liters each) and one 10 l water can (on the average, 22 liters of "mangidy" in total) (Fig. 2 A/B).

Fig. 2. A. Set of herbal teas with the part used inside the plastic bottles and the water can. B. Set of herbal teas without the part used inside. C., D., E. Stands with herbal teas sold with other products. F. Place where one vendor sold his herbal teas

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A cup of herbal tea generally costs 100 Ariary (< $ 0.05, at an exchange rate of 3500 Ariary / US dollar) but can be as high as 500 Ariary for tea with special compositions or for tea with specific effects (e.g. aphrodisiac tea). Thus, the "mangidy" beverage is a commodity that is affordable for anyone in Madagascar. On average, a vendor can sell two sets of herbal tea a day, which means a "mangidy" vendor can earn 7000 to 15000 Ariary daily, i.e. about 77% to 165% of the minimum wages in the non-agricultural sector in Madagascar. Along with the beverages in the plastic bottles and the water can, each vendor also brings a bucket of clean water to wash the drinking cups as well as to put the plastic bottles.

"Mangidy" vendors purchase the plant species needed for the tea preparation every three to seven days from herb sellers (herbalists or "Mpivarotra tapa-kazo") located in Antananarivo at three different marketplaces called Isotry, Petite-Vitesse, and Andravoahangy (Fig. 1). However, when vendors cannot find the plant species they are looking for at one of the usual locations, they try to acquire it from either one of the nearby countryside villages or towns, like Ambatolampy, Ambohimandroso, Anjozorobe, Antsirabe, and Manjakandriana, or order it from districts that are farther away, like Mahajanga and Toliara where the plant species is available.

Generally, "mangidy" sellers reported receiving their traditional knowledge about plant uses from their fathers, grandfathers, or other close relatives (e.g. uncles). However, there are some sellers who have gained their knowledge directly from herbalists that they know and which, once they believe they have the requisite knowledge, then allowed them to start their own business. All vendors interviewed during this study consider selling "mangidy" as their main or primary source of income. Some of them have been staying in Antananarivo and selling "mangidy" for more than 30 years.

Sixty-six percent (66%) of the non-vendor informants were loyal customers. They were mostly men with daily jobs that required physical strength and energy. Consumers of "mangidy" ranged from children to adults and from 3 years old to 60 years old and beyond. However, typically children were accompanied by their parents whenever they have to buy "mangidy" as parents sometimes allow their children to drink one glass of "mangidy" per day. Because of the bitter taste of "mangidy", sometimes the parents add sugar to it to make it easier for kids to consume.

Regarding the frequency of drinking herbal tea, loyal customers drink "mangidy" at least two times a week, but some of the more regular consumers also visit "mangidy" vendors when they feel that their body needs a bitter beverage or when they feel sick. Loyal consumers drink one to three glasses of "mangidy" a day and they believe that the effect of the "mangidy" sold on the streets is different from the one they prepare for themselves at home. Conversely, 34% of the non-vendor informants affirmed that they never drink the herbal beverages sold on the streets because they are concerned about hygiene during the preparation stage and are also concerned about unknown side effects.

Informants' knowledge

During the survey, 24 plant species belonging to 24 genera and 21 families were recorded (Table 1). The plant families are all represented by one species except Asteraceae and Meliaceae, which have three and two species each, respectively. Two of the 24 genera (*Cedrelopsis* and *Neobeguea*) are endemic to Madagascar. At the species level, 10 of the 24 species are endemic to the island. In terms of growth forms, seven species are trees, five are shrubs, seven are herbs, and five are lianas.

The 24 listed species obtained from the survey were reported to be used to treat 36 health problems and they were classified within 11 sub-categories of the medicinal and veterinary category, according their medicinal properties. The results showed that most of the species were used to help the digestive system (17 species), general ailments (14 species), reproductive system (13 species), and the muscular-skeletal system (10 species). However, *Aloe macroclada* has been generally used as an additive and sold in the market in the form of small hand-rolled black pellets (Fig. 3). The species distribution in each sub-category is presented in Fig. 4.

Fig. 3. Pellets of *Aloe macroclada*

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Table 1. Plant species used in “mangidy” beverages around Antananarivo, the capital city of Madagascar

Family Scientific name	Malagasy common names	Medicinal use	Parts used	Endemism	Voucher numbers
Acanthaceae *Avicennia marina* (Forssk.) Vierh.	Afiafy	Hyperglycemia, stomach-ache, syphilis	Leaves	Not Endemic	MTR 142; RNH 808
Apocynaceae *Pentopetia androsaemifolia* Decne.	Tandrokosy	Asthenia, hepatitis, hyperglycemia, stomach-ache, syphilis	Stem	Not Endemic	MTR 189; ATH 1891
Araliaceae *Neocussonia* sp. (Harms) Hutch.	Marivoravina	Stomach-ache	Leaves		
Asphodelaceae *Aloe macroclada* Baker	Aloesy, Vahona	Amenorrhea, asthenia, constipation, cough, fever, gonorrhea, jaundice, stomach-ache, urinary retention, urticaria	Resin, leaves	Endemic	MTR 139; RVN 287
Asteraceae *Distephanus polygalifolius* (Less.) H. Rob. & B. Kahn	Ninginingina	Hyperglycemia	Leaves	Endemic	MTR 136; ST 1378
Inulanthera brownii (Hochr.) Källersjö	Kelimavitrika	Asthenia, hyperglycemia, stomach-ache, syphilis	Leaves	Endemic	MTR 128
Senecio canaliculatus Bojer ex DC.	Ramijaingy	Hyperglycemia	Whole plant	Endemic	MTR 201; MAR 489
Bignoniaceae *Phyllarthron bojeranum* DC.	Zahana	Cough, gonorrhea, hyperglycemia, lower back pain, lumbago	Leaves	Endemic	MTR 175; ASR 339
Boraginaceae *Symphytum orientale* L.	Kaonsoda	Stomach-ache	Leaves	Not Endemic	MTR 203
Cactaceae *Cereus triangularis* (L.) Haw.	Fakatsilo	Appendicitis, asthenia, back pain, gonorrhea, gout, hepatitis, hypercholesterolemia, hyperglycemia, kidney failure, kidney stone, lower back pain, lumbago, prostatitis, stomach-ache, urinary retention, urticaria	Roots	Not Endemic	MTR 158
Celastraceae *Mystroxylon aethiopicum* (Thunb.) Loes.	Fanazava	Amenorrhea, asthenia, back pain, cough, fever, gout, hepatitis, hyperglycemia, kidney failure, lower back pain, stomach-ache, syphilis, urticaria	Leaves	Not Endemic	MTR 126; RJQ 647
Fabaceae *Senna occidentalis* (L.) Link	Tsotsorinanga atra	Gonorrhea	Leaves	Not Endemic	MTR 165; TAB 300
Lauraceae *Cinnamomum camphora* (L.) J. Presl	Ravintsara	Abdominal pain, asthma, back pain, cough, fever, gout,	Leaves	Not Endemic	MTR 122

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		hepatitis, hyperglycemia, stomach-ache, syphilis			
Lygodiaceae *Lygodium lanceolatum* Desv.	Karakaratolo ho	Asthenia, hyperglycemia, stomach-ache	Leaves	Not Endemic	MTR 157; RKN 446
Lythraceae *Woodfordia fruticosa* (L.) Kurz	Lambohenja na	Asthenia, back pain, cough, erectile dysfunction, lower back pain, lumbago, rheumatism, toothache	Roots	Not Endemic	AP 8653
Malvaceae *Cola nitida* (Vent.) Schott & Endl.	"Cola"	Asthenia, erectile dysfunction	Seeds	Not Endemic	
Meliaceae *Azadirachta indica* A. Juss.	Nimo, "150 maladies"	Abdominal pain, amenorrhea, asthma, cough, diabetes, fever, gout, hepatitis, hypoproteinemia, stomach-ache	Leaves	Naturalized	MTR 124; ATH 845
Neobeguea mahafaliensis J.-F. Leroy	Andy, Handy	Asthenia, back pain, erectile dysfunction	Bark	Endemic	MTR 183; MNH 334
Molluginaceae *Paramollugo nudicaulis* (Lam.) Thulin	Aferotany	Abdominal pain, asthma, cough, fever, gout, hemophilia, hyperglycemia, stomach-ache, syphilis, urinary retention, urticaria	Whole plant	Not Endemic	MTR 178; RKN 485
Orchidaceae *Vanilla madagascariensis* Rolfe	Vahinamalo	Asthenia, cough, erectile dysfunction, lower back pain, rheumatism, toothache	Stem	Endemic	MTR 208; ATH 1987
Poaceae *Zea mays* L.	Katsaka	Gonorrhea	Stigma	Not Endemic	MTR 156
Primulaceae *Embelia concinna* Baker	Tanterakala	Hyperglycemia	Leaves	Endemic	MTR 206
Rutaceae *Cedrelopsis grevei* Baill.	Katrafay	Abdominal pain, asthenia, back pain, cancer, cough, erectile dysfunction, flu, gout, hyperglycemia, kidney stone, lower back pain, obesity, syphilis	Bark	Endemic	MTR 141; CR 6022
Stilbaceae *Nuxia capitata* Baker	Valanirana	Amenorrhea, high blood pressure, hypercholesterolemia	Leaves	Endemic	MTR 15, 169; ALH 387

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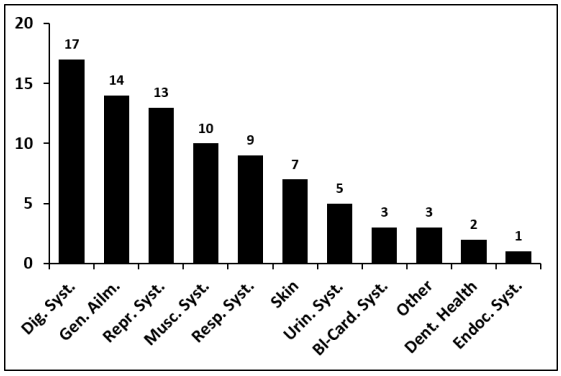

Fig. 4. Number of species used per sub-category of uses (Dig. Syst.: Digestive System, Gen. Ailm.: General Ailments, Repr. Syst.: Reproductive System, Musc. Syst.: Muscular-Skeletal System, Resp. Syst.: Respiratory System, Urin. Syst.: Urinary System, Bl-Card. Syst.: Blood and Cardio-vascular System, Dent. Health: Dental Health, Endoc. Syst.: Endocrine System)

Out of a total of 312 citations (a species mentioned for a use by an informant) recorded in this study, figure 5 shows that the number of citations varies also from one sub-category of uses to another. Most citations were recorded for digestive system with more than two times citations than the others. The use of the 17 species for this sub-category can be then considered as important. However, species used for urinary system were as well remarkably pertinent as they were cited 24 times with five species.

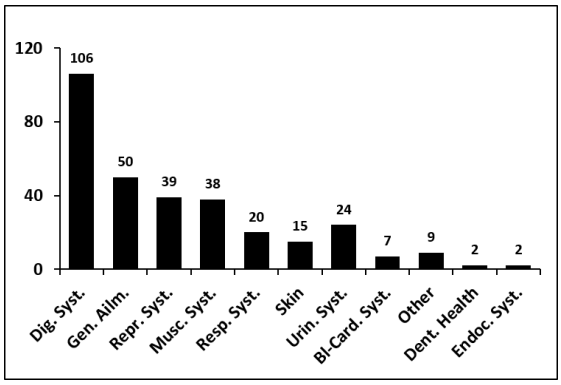

Fig. 5. Number of citations recorded per sub-category of uses

With regard to species citation frequency, 11 species of which five are endemic had at least 20% of citation frequency (CF). The results are shown in Table 2 with the number of health problems recorded for each species.

Table 2. Top 11 species with CF $\geq$ 20%

Species	**Citation frequency (%)**	**Number of health problems recorded**
Cedrelopsis grevei	77	14
Cereus triangularis	73	16
Paramollugo nudicaulis	60	11
Cinnamomum camphora	53	10
Mystroxylon aethiopicum	40	13
Aloe macroclada	40	10
Woodfordia fruticosa	33	8
Azadirachta indica	30	10
Inulanthera brownii	23	4
Neobeguea mahafaliensis	23	4
Vanilla madagascariensis	20	6

In terms of frequently cited health problems, the top 10 are asthenia (90% CF), stomach-ache (64.5% CF), hyperglycemia (58% CF), erectile dysfunction (55% CF), kidney stone (39% CF), hepatitis (32% CF), cough (29% CF), kidney failure (26% CF), lower back pain (26% CF) and syphilis (23% CF). With respect to the plant part used, leaves are mostly used (54% of the species). Both decoction and infusion were the methods used to prepare the tea, which is taken orally by the consumers. The species mainly used for the 10 most frequently cited health problems are shown in Table 3 with their corresponding number of citations.

Table 3. Species mainly used for the 10 most frequently cited health problems

Health problems most frequently cited	**Species mostly used (number of citations for each health problem)**
Asthenia	*Cedrelopsis grevei* (22)
Stomach-ache	*Cinnamomum camphora* (9)
Hyperglycemia	*Paramollugo nudicaulis* (12)
Erectile dysfunction	*Woodfordia fruticosa* (9)
Kidney stone	*Cereus triangularis* (11)
Hepatitis	*Azadirachta indica* (5)
Cough	*Paramollugo nudicaulis* (4)
Kidney failure	*Cereus triangularis* (8)
Lower back pain	*Cedrelopsis grevei* (4), *Woodfordia fruticosa* (4)
Syphilis	*Paramollugo nudicaulis* (5)

Table 3 indicates that six of the eleven species cited in Table 2 were used to treat those health problems. *Cedrelopsis grevei* is mainly used for both asthenia and lower back pain, *Woodfordia fruticosa* for

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erectile dysfunction and lower back pain, *Cereus triangularis* for all kidney problems such as kidney stone, i.e. for treatment and prevention, and *Paramollugo nudicaulis* for hyperglycemia, cough and syphilis.

Different plant compositions can be found in different varieties of teas at each "mangidy" stand depending on what the sellers want to sell or on what the consumers need. This is especially true for the herbal teas contained in water cans. We found that teas in water cans primarily include *Paramollugo nudicaulis* at 69%, and without this plant species at 31% of cases. At 42% of cases, the sellers opt to add other herbs to create special tea beverages with very different properties. The species that are most typically mixed with *Paramollugo nudicaulis* are *Mystroxylon aethiopicum*, *Inulanthera brownii* and *Cinnamomum camphora*.

In terms of beverage mixtures, including those in water cans, usually two to five species are used per composition; the highest number of plant species cited by any of the interviewees that could be used to make the different mixtures was 13. Sellers make special tea beverages with specific plant species composition to treat specific ailments. While sellers are very discreet, and almost secretive about these specific compositions, during our survey, we recorded a few of the mixture recipes. For example, for those in plastic bottles, we recorded that *Cedrelopsis grevei*, *Neobeguea mahafaliensis*, *Vanilla madagascariensis* and *Woodfordia fruticosa* are a widely used remedy for erectile dysfunction. To make those beverages with much stronger effects, sellers mix *Cedrelopsis grevei* with either *Woodfordia fruticosa* or *Neobeguea mahafaliensis* and *Woodfordia fruticosa* with *Vanilla madagascariensis*.

Discussion

Worldwide, many people, especially those from developing countries, have been using natural or traditional medicine to treat various ailments (WHO 2007). Informal systems of herbal mixtures in beverage form are not well documented but have been recorded in other areas of the world for therapeutic purposes. For example, the "horchata" drink has been sold in Southern Ecuador to improve human's wellbeing (Rios *et al.* 2017). A total of 71 medicinal plant species were recorded for this drink with 32 kinds of therapeutic uses. In Peru, "emolientes" were also consumed originally to improve digestion and further to treat illnesses (Bussmann *et al.* 2015). A total of 42 species were registered for the preparation of "emoliente". In this present study, 24 species were recorded and supposed to address 36 health problems. Unsurprisingly, given the endemism of the Malagasy flora, this study has little in common with these prior studies in terms of species list or species used to create the beverage to treat the same disease. However, both our study and that of Rios *et al.* (2017) emphasized that leaves are the most frequently used plant part, and digestive system was among the most common health problems treated. Furthermore, the three studies all highlight the importance of doing more researches and experiments to determine the appropriate doses or posology of herbal mixture and to understand any secondary effects.

According to interviewed consumers, who seem to have very little concern for negative secondary effects, "mangidy" beverages are very effective as it helps to prevent or to rid them of their ailments. Our analysis in this present study indicates that the "mangidy" beverages are considered useful for some common health problems, such as asthenia and stomach-aches. Indeed, previously conducted and published researches show some evidence of potential health benefits for nine of the 11 species that had high citation frequency in this study. The available information regarding nine of the species listed during this study is briefly reviewed in the following paragraphs.

Aloe macroclada was traditionally thought to help rejuvenate the body and increase lifespan and has been used for centuries by Malagasy people as a remedy for a wide variety of ailments including cardio-vascular diseases, hypertension, pulmonary infections, rheumatism, asthenia, and diabetes (Drapeau *et al.* 2015). From our study, it appears that *Aloe macroclada* is only used as an additive in the "mangidy" beverages. It is used in a form of small hand-rolled pellets and only two to four pellets per cup or glass are used. According to one of the interviewed sellers for this study, generally, only adults administer these pellets since they can be harmful to those who cannot tolerate the effect of the compounds they contain.

Azadirachta indica has been reported to be the most useful traditional medicinal plant in India as it is used to develop remedies against various diseases (Biswas *et al.* 2002) and employed as a treatment for a broad array of health concerns (Pankaj *et al.* 2011). During this study, we discovered that this plant species has been nicknamed "150 maladies" (150 illnesses or "aretina 150") due to its perceived wide biological activities range that allows it to cure multiple diseases. Although some authors argue that *Azadirachta indica* is considered harmless to

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humans, others caution that it can be harmful when used at high doses (Nicolas 2012).

Cedrelopsis grevei and *Cinnamomum camphora* are known for their essential oils and usage by the traditional pharmacopoeia (Andrianoelisoa 2013; Frizzo *et al.* 1999). They are also well-known in Madagascar for their strong medicinal and economic potential. *Cedrelopsis grevei* possesses toning, stimulating and fortifying properties and has been reported to have been used in traditional Malagasy medicine to combat high blood pressure, muscle fatigue, asthenia, rheumatism, and the flu, while also being used as an anti-gonorrheal aide and aphrodisiac (Rabesandratana 1976; Rakotoarison *et al.* 2009; Ratsimamanga & Rasoanaivo 2005). Furthermore, *Cedrelopsis grevei* has also been traditionally used to fight fever, scabies, boils, diarrhea, asthenia, malaria, and angina (Randevoson 2004). However, the same author suggested not to use *Cedrolepsis grevei* in herbal medicine without serious toxicological tests as in her study she observed signs of possible levels of toxicity for this species.

Woodfordia fruticosa, found natively in many parts of Madagascar, is a well-documented species reported to have interesting compounds with valuable medicinal properties (Meena & Satish 2015). For example, according to Mihira *et al.* (2011), the root of this species has the ability to counteract ulcer activities. Verma *et al.* (2012) also indicated that the ethanolic extract from the flowers of this species has anti-hyperglycemic effects, validating its traditional use to treat diabetes. Razanadimby (2013) and Nicolas (2012), from their independent research, reported the use of this species in cases of muscular fatigue and erectile dysfunction, confirming the information we obtained during our survey and reported in this study.

According to Ratsimiala-Ramonta *et al.* (2009), traditionally *Neobeguea mahafaliensis* is used to treat high blood pressure and erectile dysfunction. From the interviews we conducted and reported in this present study, *Neobeguea mahafaliensis* is an aphrodisiac species, as similarly stated by Ratsimiala-Ramonta in her 2009 study.

Other species such as *Cereus triangularis*, *Paramollugo nudicaulis*, and *Mystroxylon aethiopicum*, which are among the species used in making the “mangidy” beverages, were also previously reported to have medicinal properties. In his study conducted in the north region of Madagascar, Petera *et al.* (2015) reported that the cactus species *Cereus triangularis* has been used to reduce stomach-aches and intestinal diseases. Nagesh & Shanthamma (2011) indicated that the leaves of *Paramollugo nudicaulis*, a widespread species growing in a great variety of habitats, have been used to cure whooping cough and jaundice. According to Sindhu *et al.* (2010), the same species also possesses anti-diabetic properties. The works of Gakunga *et al.* (2014) and Nicolas (2012) in communities in Uganda and Northern Madagascar, respectively, revealed that *Mystroxylon aethiopicum* was used in traditional herbal remedies to treat erectile dysfunction, asthenia and fever.

Experimental trials have also tested some of the plant species used to make “mangidy”. For example, the experiments conducted by Razanadimby (2013) with three different models (mouse, guinea pig, human) indicated that the decoction of a mixture of *Cedrelopsis grevei*, *Woodfordia fruticosa* and *Paramollugo nudicaulis* did not significantly affect the three major physiological functions studied, namely hepatitis, renal, and cardiac functions. According to the author, this mixture could find therapeutic benefits in the treatment of heart failure by its positive inotropic effect.

Despite this evidence that plant decoctions or plant infusions can be effective, there is little evidence and no guidelines for dosages and how much one should consume to treat a particular ailment. To date, there is no scientifically published conventional dosage for any particular plant species for a particular illness with regard to “mangidy” beverages. This is a potential danger for such a popular group of medicinal plants. Rafatro *et al.* (2005) already reported the negative side effects of over-using the “mangidy” beverage made with *Paramollugo nudicaulis*. Due to this lack of information, in Madagascar, the consumption of “mangidy” beverages is not recommended by physicians. During our field interviews, consumers of “mangidy” did not express nor exhibit any side effects of consuming “mangidy” beverages despite long periods of consumption. Seemingly, the consumers rely on the word of the sellers of the beverages they drink and thus they will continue to drink “mangidy” beverages despite the risk mentioned above. However, 34% of public interviewees avoided drinking “mangidy” because of concerns about side effects.

With respect to the supplies of plant species used to make “mangidy” and referring to the work done by Randriamiharisoa *et al.* (2015) on medicinal plants sold in Antananarivo markets, we noticed that some plant species like *Cedrelopsis grevei*, *Cereus triangularis* and *Neobeguea mahafaliensis* were

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frequently sold by herbalists and “mangidy” sellers. Conversely, species such as *Paramollugo nudicaulis*, *Cinnamosma camphora*, *Mystroxylon aethiopicum*, *Aloe macroclada*, *Azadirachta indica* and *Vanilla madagascariensis* are not frequently sold in the market, suggesting that “mangidy” sellers obtain their plant merchandises from other regions of Madagascar. The most rarely traded plant species are *Woodfordia fruticosa* and *Cola nitida* even though they are known to be used in “mangidy” beverages.

Conclusions

“Mangidy” beverages are a popular form of medicine found in Madagascar’s capital of Antananarivo. “Mangidy” beverage stands can be found in many corners of Antananarivo’s market streets. The results of our study indicate that there are 24 plant species used to make “mangidy” beverages, which can be used individually or mixed together in several different concoctions depending on the buyer’s needs. The most cited used species are *Cedrelopsis grevei*, *Cereus triangularis*, *Paramollugo nudicaulis* and *Cinnamomum camphora*. We believe these particular species are rather popular due to either their wide healing range or the commonality of certain ailments in the population, including abdominal pain, asthenia, asthma, back pain, cough, erectile dysfunction, fever, gout, hepatitis, hyperglycemia, kidney stone, lower back pain, stomach-ache, syphilis and urinary retention. Given that information, during this survey, we documented about 36 ailments that “mangidy” beverages are used to treat. The range goes from common ailments, like asthenia or stomach-aches, to more specific ailments such as erectile dysfunction or hyperglycemia. Indeed, ingesting “mangidy” beverages or other traditional remedies based on the healing power of plants is part of Malagasy tradition. Similar to other parts of the world, Malagasy people have significant traditional knowledge on plant uses. They use their knowledge and drinking “mangidy” beverages in Antananarivo is a perfect illustration. Many people in Madagascar drink a “mangidy” beverage every day to treat or to prevent illnesses but unfortunately, they do not pay attention to its potential side effects. Given all the potential side effects of drinking “mangidy” beverages, it is imperative to have the government health officials, physicians, and scientists who are studying these traditional medicines to work collaboratively with traditional healers to find ways to regulate the consumption of this popular beverage so it can do more good than harm to people in Madagascar.

Declarations

List of abbreviations:
Bl-Card. Syst.: Blood and Cardio-vascular System
CF: citation frequency
Dent. Health: Dental Health
Dig. Syst.: Digestive System
Endoc. Syst.: Endocrine System
Gen. Ailm.: General Ailments
Musc. Syst.: Muscular-Skeletal System
Repr. Syst.: Reproductive System
Resp. Syst.: Respiratory System
TAN: Madagascar national herbarium of Tsimbazaza
Urin. Syst.: Urinary System

Ethics approval and consent to participate: The study was performed following the Protocol of Nagoya on Access and Benefit Sharing.

Consent for publication: Not applicable.

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FANADIHADIANA

▪ Daty : ……..
▪ Toerana : …….
▪ N° : …….

Olona nanontaniana :

▪ Sokajy : Lahy □ Vavy □
▪ Taona : ……
▪ Fiaviana : ……

A. Fanontaniana ho an'ny mpivarotra :

- Inona avy ny karazan-javamaniry ampiasainao hanaovana mangidy?
  ……
  ……
- Inona no hampiasana azy?
  ……
  ……
- Ahoana no fomba fikarakarana azy?
  Ampangotrahina □ Alòna anaty rano □ Hafa □ : ……...
- Misy zavamaniry miaraka afangaro ve? Eny □ Tsia □ Inona avy?
  ……
  ……
- Taiza ianao no nianatra ny fanamboarana mangidy?
  ……
- Ianao ihany ve no mamboatra azy? Eny □ Tsia □
- Aiza ny toerana hakàna na hividianana azy?
  ……
- Isaky ny inona no manafatra na mividy? ……..
- Firy taona izay no nanaovanao io asa io? …….
- Aiza avy ny toerana ivarotanao? ……...
- Ohatrinona ny vidin'ny iray vera? ……..
- Mahalafo firy litatra ianao anatin'ny iray andro? …….
- Karazan'olona manao ahoana no mividy mangidy?
  ……
- Firy taona eo ho eo ny olona mividy mangidy? .....
- Inona no be mpisotro indrindra?
  ……
- Mety misy tsy mahazaka ve? Eny □ Tsia □
  ……

B. Fanontaniana ho an'ny mpividy sy olon-tsotra :

- Ianao ve misotro mangidy? :
  Eny □
  - Inona no antony hisotroanao mangidy?
    ……..
  - Inona amin'ireny no tena fisotronao?
    ……
  - Isaky ny inona ianao no misotro? ……..
  - Firy vera no sotroinao isaky ny misotro? ……..
  - Tsy mbola nisy vokatra ratsy ve tsapanao tamin'ny fisotroana azy?
    …….

  Tsia □
  - Inona no antony tsy hisotroanao azy? ……
    …….

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