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Ethnochemometric of plants traditionally utilised as local detergents in the forest dependent culture

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ABSTRACT

The purpose of this study is to access the existing awareness of nearly forgotten Thai detergent plants by the use of chemometrics tool. A Northern Thai forest dependent community was chosen as it played vital role on knowledge retaining of plant utilisations. For initial perception, ethnobotanical survey was conducted to determine usage of plants by the community. Then the utilised plant parts were screened for phytochemicals and their relationships with the defined cleansing terms (viz., shampoo, scrub, detergent, soap, scent and spiritual) were analysed by Principal Component Analysis (PCA). From the results, the most cited plants as known, used and found were *Acacia concinna*, *Clitoria ternatea*, *Oryza sativa* and *Citrus hystrix*. Biometric analyses advised that knowledge of detergent plant utilisation was well preserved at all age ranges and it was not variable with genders. Cluster analysis described that term 'spiritual' was not narrated with cleansing properties. For phytochemical analysis, plant extracts showed positive variable of bioactive ingredients and the main compounds in the extracts was saponins. These findings confirmed that the knowledge of indigenous plant utilisation was reserved by the forest dependent community and the information is beneficial toward local plant conservation movement.

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1. Introduction

Traditionally ecological knowledge represents the human experience acquired over thousands of years from the direct contact with the environment (Berkes, 1993; Srithi et al., 2012; Turner et al., 2000). Anthropogenic pressures such as invasion of cash crops and expansion of urbanisation have threatened the richness of local plant species and their biological complexities. Moreover,

the knowledge of indigenous plant utilisation is at risk of loss due to the limit biodiversity as well as the replacement of chemical-synthesis products. By using ethno-informatic documentation, the traditional knowledge could be well preserved and reinforce the better understanding between local communities and plants, which is, in turn, essential to support biodiversity conservation (Almeida et al., 2014; Hoekou et al., 2016; Nankaya et al., 2019; Srithi et al., 2012). It is commonly concurred that forest dependent community plays an important role for retaining knowledge of natural resource utilisation and possess as frontliner for the assessment of loss of traditionally ecological knowledge (Stibig et al., 2014).

Thai people have historically reaped the benefits of native detergent plants with cleansing properties over hundreds of years. These group of plants contain main bioactive compounds which are saponins, known as bio-based surfactants (Bouillon, 1996; Kregiel et al., 2017; Oleszek and Hamed, 2010; Osbourn, 1996). Need for these valuable active ingredients has ramped-up along

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with the urge for the replacement of chemical synthesis that is harm our environment, however, the knowledge of Thai local plants used for cleansing purposes is being declined (Wisetkomolmat et al., 2019). Moreover, scientific evidences regarding the perception of local detergent plants as well as terms to describe detergent properties are somewhat confusing (Inta et al., 2013). Wisetkomolmat et al. (2019) documented the list of plants utilised as for cleaning purposes by Thai ethnic groups. Nonetheless, the analyses regarding to their physiochemical functionalities, particularly to describe detergent properties have yet been elucidated anywhere.

The multivariate Principal Component Analysis or PCA is the most fundamental method used in chemometric (Esbensen and Geladi, 2009). This method reduces data dimension by geometrical projection analogy and visually cluster the variants using principal components. For this instance, this tool has been used in many fields, including the biochemistry and biology (Lever et al., 2017; Roessner et al., 2011). To fill the gaps mentioned above, the valuable ethno-informatic data from a forest dependent community as well as the presence phytochemicals from the collected plant species were gathered. Taking the advantage of chemometrics, we hoped to be able to fully comprehend the status of the current knowledge and terms used to describe our local detergent plants. The result from our study could validate urge for local plant conservation driven by existing social knowledge.

2. Materials and methods

2.1. Study area

The forest dependent community chosen was located in Doi Sa Ket district (location: 18.8407128, 99.199082), ~ 50 km out-skirt to the North of the urban Chiang Mai city, Thailand (Fig. 1). According to population data in 2018, the district had an estimated total number of 73,500 habitants. The majority of the residents are largely subsistent famers with some engagement in agroforest system. Inter-connecting between Chiang Mai urban city and the forest, the community has resided and employed the benefits of

natural resources from the forest reserve restored by the Huai Hong Khrai Royal Development Study Centre (HHKC), for almost 40 years. The forest represents one of the highly fertile areas and riches with local plant biodiversity.

2.2. Bio- and ethno-informatic data collection

The general terms used to describe cleansing purposes including; 'shampoo', 'scrub', 'detergent', 'soap', 'scent' and 'spiritual cleansing' were generated from our previous study and also list of the plants used for same purposes in Northern Thai areas from various ethnobotanical documents (Wisetkomolmat et al., 2019) (Table 1). The total of 68 interviewees were randomly selected based on the length of time that they resided in this community (>20 years). They also represented a single race. After a brief explanation of the study objectives, a consent was informed and all participants were asked to sign a consent form certifying their agreements (Dos Santos et al., 2009; Hoekou et al., 2016; Monteiro et al., 2014). The ethnobotanical surveys were conducted between January to May 2019. All of personal identification data was eliminated after analysed. Prior to conducting the survey, semi-structured questionnaire was constructed in which it was composed of two parts (Martin, 2010). The first part was interviewee general information (age and gender) and the second part was consisting of (i) general questions that included a binary respond type (yes/no) asking if they recognised the plants and their local names from the prepared pictures, seen/found these plants in the area and utilised those plants (ii) an open interview of plant utilisation in cleansing purposes (viz., plant part used and how they used them). The binary data was used to calculate degree of recognition (%DR), degree of found (%DF), and utilisation value in general (%UV) by using number of times a particular species was mentioned divided by total number of interviewees and multiply by 100 (Faruque et al., 2018). For, the use value of the specific species used in cleansing purposes (UVs) was according to Monterio et al. (2014) and Hoffman and Gallaher (2017) which is calculated from the following equation;

$$UVs = (UR)/(Ni) \quad (1)$$

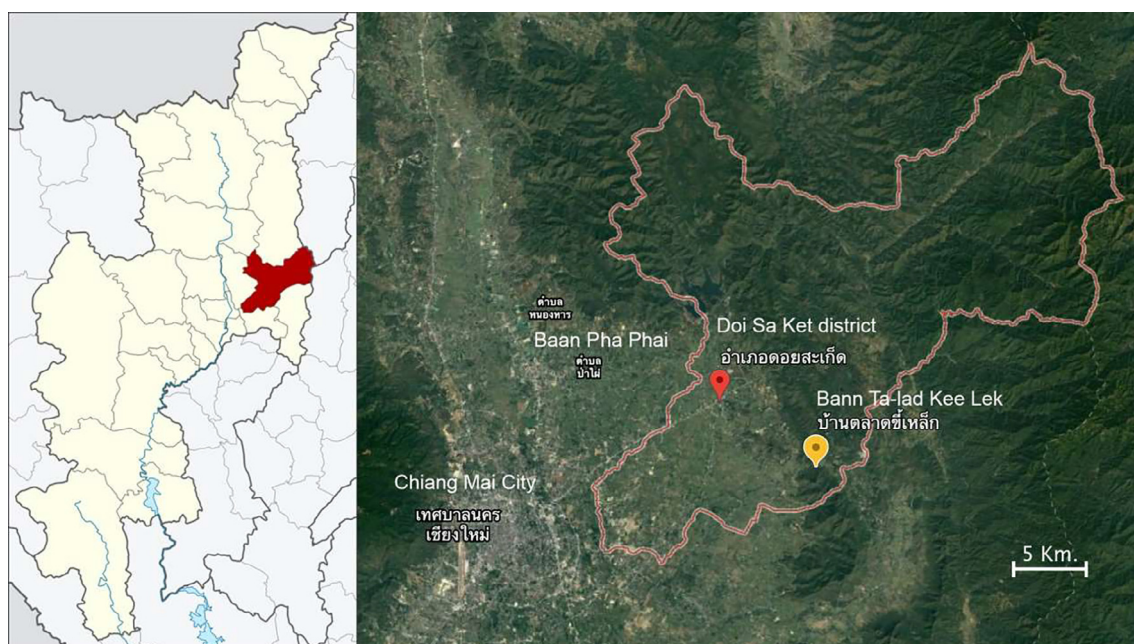


Fig. 1. Study site in the forest dependent community chosen located in Doi Sa Ket district, Chiang Mai, Thailand.

Table 1
Detergent plants used by a Huai Hong Khrai reserved forest independent community.

S. No.	Family name	Plant scientific name	Local name	Part used as Detergent	UV _s in Cleansing purposes (Preparation)	Degree of recognition (%)	Degree of found (%)	UV in general (%)
1	Acoraceae	<i>Acorus gramineus</i> Aiton.	Waan Nam Lek	Leaf	0.029 (Mashed in water as detergent and gave a scent)	42.6	45.6	29.4
2	Arecaceae	<i>Calamus</i> sp.	Wai	Leaf	–	94.1	89.7	61.8
3	Burseraceae	<i>Garuga pinnata</i> Roxb.	Ta Kram	Leaf	0.059 (Mashed and used as shampoo)	10.3	20.6	8.8
4	Cucurbitaceae	<i>Luffa cylindrica</i> Roem.	Buab Khom	Fruit	0.735 (Fibre of dried fruit is used as similar to cleansing sponge)	97.1	94.1	91.2
5	Cucurbitaceae	<i>Trichosanthes cucumerina</i> Linn.	Buab Ngoo	Fruit	0.162 (Fibre of dried fruit is used as similar to cleansing sponge)	82.4	82.8	67.6
6	Dilleniaceae	<i>Dillenia parviflora</i> Griff.	San Hing	Fruit	–	8.8	20.6	2.9
7	Euphorbiaceae	<i>Antidesma acidum</i> Retz.	Mao Sroi	Leaf	–	79.4	77.9	64.7
8	Euphorbiaceae	<i>Homonoia riparia</i> Lour.	Khrai-Naam	Leaf	0.162 (Detergent for hand wash)	54.4	58.8	20.6
9	Euphorbiaceae	<i>Flueggea virosa</i> (Willd.) Voigt	Kang Pla Kao	Stem	0.015 (Mashed and soaked in water used as shampoo)	22.1	30.9	13.2
10	Fabaceae	<i>Acacia concinna</i> (Willd.) D.C.	Som Poi	Fruit	1.029 (Dried fruit is used for spiritual cleansing during Thai new year by soaking in water)	100	98.5	94.1
11	Fabaceae	<i>Clitoria ternatea</i> L.	An-chan	Flower	0.765 (Mashed and mixed with soap or shampoo)	100	100	97.1
12	Hypoxidaceae	<i>Curculigo latifolia</i> Dryand. ex. W.T. Aiton	Wan Sak Lek	Tuber	–	30.9	39.7	7.4
13	Lauraceae	<i>Litsea glutinosa</i> (Lour.) C.B. Rob.	Mhee	Leaf	0.456 (Leaves are mashed and soaked in water to be used as shampoo ingredients)	52.9	54.4	35.3
14	Oxalidaceae	<i>Oxalis corniculata</i> L.	Som Kob	Leaf	0.162 (Used to polish silver wares)	76.5	80.9	58.8
15	Pedaliaceae	<i>Sesamum orientale</i> L.	Nga	Leaf	0.015 (Used as scrub)	97.1	97.1	92.6
16	Poaceae	<i>Oryza sativa</i> L.	Kao, Kaw	Pericarp	0.500 (Pericarp is used as similar to cleansing sponge or mixed in soap and shampoo)	98.5	100	97.1
17	Rutaceae	<i>Citrus hystrix</i> D.C.	Ma Krud	Fruit	1.853 (Mashed and soaked in water used as shampoo or detergent)	98.5	100	100
18	Salicaceae	<i>Salix tetrasperma</i> Roxb.	Khrai Bok	Pericarp	0.015 (Used as detergent)	20.6	22.1	11.8
19	Sapindaceae	<i>Aesculus assamica</i> Griff.	Ma Niang Nam	Leaf	0.059 (Used as shampoo)	23.5	25.0	13.2
20	Oxalidaceae	<i>Sapindus rarak</i> D.C.	Ma Kham Di Khwai	Pericarp	0.559 (Mashed and soaked in water used for cleansing clothes)	63.2	64.7	51.5
21	Solanaceae	<i>Solanum erianthum</i> D. Don	Dap Yang	Leaf	–	25.0	27.9	11.8
22	Malvaceae	<i>Microcos tomentosa</i> Sm.	Phlap-phla	Leaf	0.015 (Mashed in water used as shampoo)	11.8	10.3	5.9
23	Vitaceae	<i>Cissus modeccoides</i> Var. Karri	Som La Op	Leaf and stem	–	2.9	7.4	1.5
24	Rutaceae	<i>Cissus repen</i> Lamk.	Tao Kan	Stem	–	17.6	26.5	10.3
25	Zingiberaceae	<i>Amomum biflorum</i> Jack.	Wan Sao Long	Rhizome	0.015 (Mashed in water used as shampoo)	27.9	30.9	10.3

Where, UV_s = species use value, UR = number of times a particular species was mentioned using in cleansing purposes, Ni = total number of informants interviewed for each species (s).

2.3. Phytochemical screening

Plant sampling for phytochemical screening was achieved by village survey trips with head of the community (Male, 55 years old) who had intensive knowledge of plants in this forest dependent community for >30 years. Only plant species from the lists that were found, either in the market or by domestication or in their natural habitats were taken from at least three adult plants and the materials corresponding to the utilised plant part for each of detergent plant species were also collected (Ahumada-Santos et al., 2013). Plant specimens were prepared according to Faruque et al. (2018) and plant species confirmation was done by comparison the specimen with those deposited at plant collection library of the ethnobotanical laboratory, Department of Biology, Faculty of Science, Chiang Mai University (CMU). The specimens

were assigned number and stored at Plant Bioactive Compound Herbarium (BACH), Department of Plant and Soil Science, Faculty of Agriculture, CMU (The assigned voucher specimen numbers are given in Table 2).

The utilised parts were separated and dried at 35 °C in a hot-air oven, then ground into fine powder using an electric grinder. The powder (10 g) of each plant was extracted by maceration with either 100 mL of methanol or water at room temperature (25 ± 2 °C) (Inalegwu and Sodipo, 2015). After 12 h, the solvents were filtered through Whatman No.1 filter paper and re-extracted the residue with the same solvent thrice. Combined supernatants were evaporated by a rotary evaporator to obtain a crude extract, kept in flask and stored at 4 °C. The preliminary qualitative phytochemical analysis was carried out to identify types of the secondary metabolites viz. alkaloids, glycosides, steroids, saponins, terpenoids, and tannins in the crude plant extracts. All of the evaluation was done by direct visual observation and the content was estimated based on a relative scale of absent and presence with low (+), medium (++) and high (+++) (Ahumada-Santos et al., 2013; Sommano et al., 2016).

Table 2

Pre-screening of bioactive compounds and total saponins content in collected plants used in cleansing purposes.

Scientific name (voucher no.)	Part used	Solvent	Alk	Gly	Ster	Sap	Ter	Tan	TSC (mg saponin/ g sample)
<i>C. hystrix</i> (JW001)	Fruit	Methanol	+	++	+	+	++	+	0.46 ± 0.09
		Water	+	++	++	+	++	+	0.24 ± 0.01
<i>S. rarak</i> (JW002)	Pericarp	Methanol	-	-	-	+++	-	-	2.66 ± 0.58
		Water	-	-	-	+++	+	+	1.88 ± 0.01
<i>A. acidum</i> (JW003)	Leaf	Methanol	-	++	++	+	++	+++	0.22 ± 0.03
		Water	-	-	+	+	+	++	0.15 ± 0.01
<i>Calamus</i> sp. (JW004)	Leaf	Methanol	++	-	++	+	+	+++	0.49 ± 0.00
		Water	++	+++	+	+	+	++	0.41 ± 0.03
<i>H. riparia</i> (JW005)	Leaf	Methanol	-	++	+++	+	++	+++	0.33 ± 0.02
		Water	-	+	+	++	++	+++	0.18 ± 0.01
<i>A. concinna</i> (JW006)	Fruit	Methanol	-	+++	+++	+++	-	-	1.15 ± 0.04
		Water	+++	+++	++	+	+++	-	0.52 ± 0.02
<i>L. glutinosa</i> (JW007)	Leaf	Methanol	-	+	-	++	++	+++	0.52 ± 0.02
		Water	+++	++	+	++	++	++	0.33 ± 0.04
<i>A. biflorum</i> (JW008)	Rhizome	Methanol	-	-	+	+	++	-	0.17 ± 0.03
		Water	-	+	++	+	+	-	0.18 ± 0.01

Symbol (+++) indicates presence in high concentration, Symbol (++) indicates presence in moderate concentration, Symbol (+) indicates presence in trace concentration, and (-) indicates absence of the respective phytochemical.

Abbreviations: Alk: Alkaloids, Gly: Glycosides, Ster: Steroids, Sap: Saponins, Ter: Terpenoids, Tan: Tannins, TSC: Total saponins content.

The values are means ± standard deviations (n = 3). Saponin content in the samples is expressed as mg of diosgenin equivalents.

2.4. Determination of total saponin content

The total saponin content was determined by the method of Makkar et al. (2007) with slight modification. Briefly, 50 µL of plant extract was mixed with 2.5 mL sulfuric acid 72% (v/v) and 0.1 mL, 8% vanillin solution in ethanol. The mixtures were incubated in a water bath at 60 °C for 10 min and then cooled with cold water. The absorbance of sample was measured at 544 nm using SPECTROstar Nano Microplate Reader (BMG LABTECH, Ortenberg, Germany). Diosgenin was used as the reference standard with saponin content expressed as mg diosgenin equivalents per gram of dried sample powder (mg DE/g DW). The final quantification of the phytochemicals is the value of mean ± SD of three measurements.

2.5. Ethical aspect

This research had minimal risk and was not clinical trial that may harm to all participants. All participants were not vulnerable to the work conducted. The author (Jiratchaya Wisetkomolmat) had attended the Human Research Ethics training conducted by Chiang Mai University Research Ethic Committee and understood the entire ethical procedure. All procedures performed in this study involving human participants were in accordance with the ethical standards (Belmont Report) and with the 1964 Helsinki declaration and its later amendments or comparable ethical standard. Informed consent was obtained from all individual participants included in the study.

2.6. Chemometric analysis

Statistical analysis based on the use of chemometric PCA was used to investigate the correlation between people traditional knowledge and plant use characteristics using Matlab software (The MathWorks, Inc., ver. 9.7, USA). In this research study, a total of seventeen variables including 'Age', 'Gender', 'DR', 'DF', 'UV', 'Soap', 'Shampoo', 'Scrub', 'Detergent', 'Spiritual cleansing', 'Scent', 'Alk', 'Gly', 'Ster', 'Sap', 'Ter' and 'Tan' were used in the analysis.

3. Results

3.1. Demographical characteristics

The total of 68 local informants in the study area was interviewed, and the majority of the respondents was female (72%) with

the age ranged between 21 and 93 years. The population comprised of 4 age-groups (<40 = 30.88%, 51–60 = 32.35%, 61–70 = 2.058%, >71 = 16.17%) as shown in Fig. 2. The dominant age range of the correspondents was between 51 and 60 years old and the average age was 53 ± 17.5 years old.

3.2. Plant recognition, visibility and utilisation

Ethnobotanical data derived from the interview is illustrated in Table 1. Within the list of 25 documented species from 21 families, the most cited as known was *Acacia concinna* (plant no. 10; soap pod) and *Clitoria ternatea* (plant no. 11; butterfly pea) (100% DR), followed by *Oryza sativa* (plant no. 16; rice) *Citrus hystrix* (plant no. 17; kaffir lime) (98.5% DR) and *Luffa cylindrica* (plant no. 4) and *Sesamun oriental* (plant no. 15) with 97.1% DR. The results also described that *Cissus modeccoides* (plant no. 23), *Dillenia parviflora* (plant no. 6) and *Garuga pinnata* (plant no. 3) were of low DR (2.9%, 8.8% and 10.3% respectively). Plants that had been mentioned as highly found were *C. ternatea* (plant no. 11), *O. sativa* (plant no. 16) and *C. hystrix* (plant no. 17) (100% DF). Following the same trend, kaffir lime was the most utilised in general (100% UV), followed by butterfly pea and rice (97.1% UV) and the third place was *A. concinna*. The less utilised plants were *C. modeccoides*, *D. parviflora* and *G. pinnata* (1.5%, 2.9% and 8.8% UV respectively). The UVs in the cleaning purposes also showed that *A. concinna* (1.029) and *C. hystrix* (1.853) were commonly used and the first

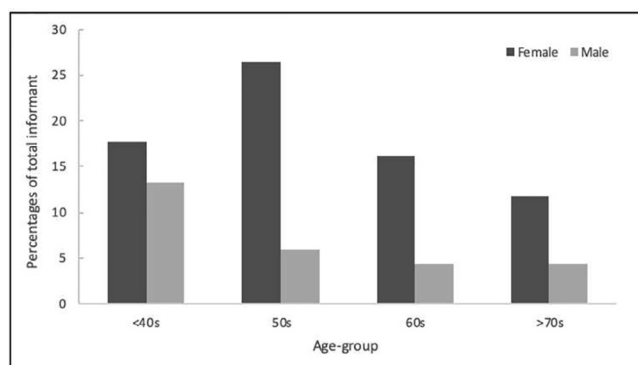


Fig. 2. Demographical characteristics.

one was known traditionally for spiritual cleansing particularly at Thai new year. For those of high UVs values (~0.5), viz. *S. rarak*, *O. sativa*, *L. glutinosa* and *C. ternetea* were of shampoo or soap ingredients. It is worthy to note that fibre from the dried fruit of both species in the Cucurbitaceae (UVs ~ 0.2–0.7) was also utilised in cleansing purposes.

The result also indicated that the plants belonging to family Fabaceae had the most cited as being recognised, visible and utilised, followed by the families Rutacea and Poaceae, while the Vitaceae was less. For plant part used as cleansing purposes, the leaf was the most utilised part, followed by fruit and the pericarp was exploitable (viz., *S. rarak* and rice). Butterfly pea was the only plant type that its flower was claimed to be used as ingredient in detergent.

3.3. Biometric analyses of detergent plant knowledge

Relationship between ages or genders of the villagers and knowledge of 25 detergent plants was analysed using the multivariate PCA in Fig. 3. In Fig. 3A, all interviewees seemed to scatter across the PCA space that accounted in PC1 15.58% and PC2 8.50%. However, it is possible to observe the cluster of the people (ages under 40 s) on the top left of the main group meaning that there could have the similarity of the traditional knowledge. From the bi-plotted shown in Fig. 3B, factors DF, UV and DR of *L. glutinosa* (plant no. 13) and UV of *O. corniculata* (plant no. 14) separated from the other plants. However, when the samples were labeled according to the gender as shown in Fig. 3C and 3D, the clusters of the gender could not be seen.

3.4. Detergent plant definition by knowledge

Terms used to describe cleansing proposes was categorised into 6 definitions as following; shampoo, scrub, detergent, soap, scent and spiritual cleansing. The relationship between such definitions and the 25 plant species (see Table 1) was illustrated in Fig. 4A. The PCA score plot (with PC1 46.70% and PC2 39.60%) illustrated that these plants can be assembled into 4 clusters. The results from the biplot analysis advised that *A. concinna* (plant no. 10) and *C. hystrix* (plant no. 17) were different from the others. Biplot cluster analysis in Fig. 4B suggested that most of the plants located in the red cycle while the rest of the plants allied with cleansing terms viz., ‘soap’, ‘detergent’, ‘scrub’ and ‘aroma’, were projected closely to each other. In addition, *C. hystrix* (plant no. 17) which projected far from the rest, had relationship with the term ‘shampoo’ more than other plants and *A. concinna* (plant no. 10) was distinct from the rest because of the term ‘spiritual cleansing’.

3.5. Phytochemical screening

Based on the survey, only eight detergent plants out of 25 species from plant list in Table 1 were collected as followed *C. hystrix*, *S. rarak*, *A. acidum*, *Calamus* sp., *H. riparia*, *A. concinna*, *L. glutinosa*, *O. corniculata*, *A. gramineus* and *A. biflorum*. Crude methanolic and water extracts gave positive for saponins when analysed the phytochemical screening by froth test and vanillin-sulfuric test (Table 2). However, alkaloids were detected only in water extract of *Calamus* sp., *A. concinna* and *L. glutinosa*. The water extract of *L. glutinosa* showed the highest variety of secondary metabolites.

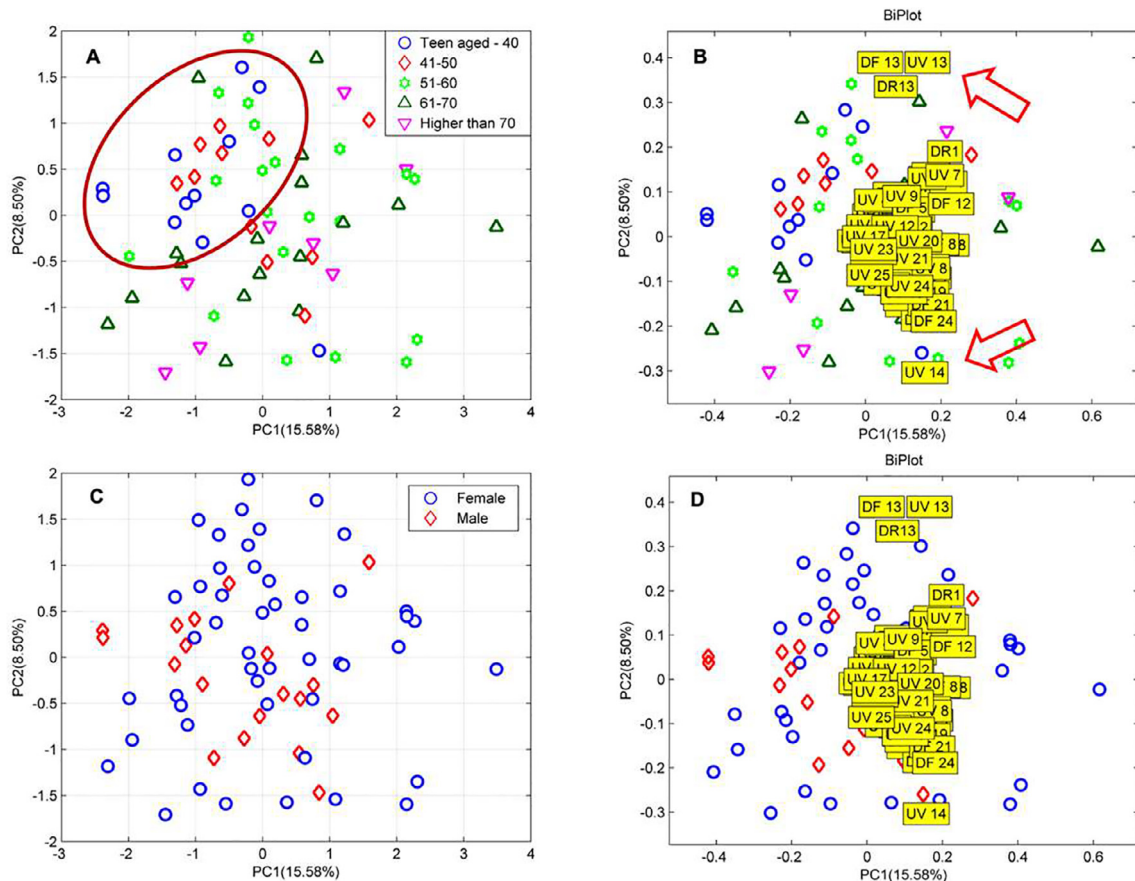


Fig. 3. Principal Component Analysis scoring of ages groups (A), gender (C) and biplot acclimations (B, D) with 25 detergent plants knowledge as defined by degree of recognition (DR), degree of finding (DF) and utilisation value in general (UV). Lists of plants are detailed according to the serial numbers listed in Table 1.

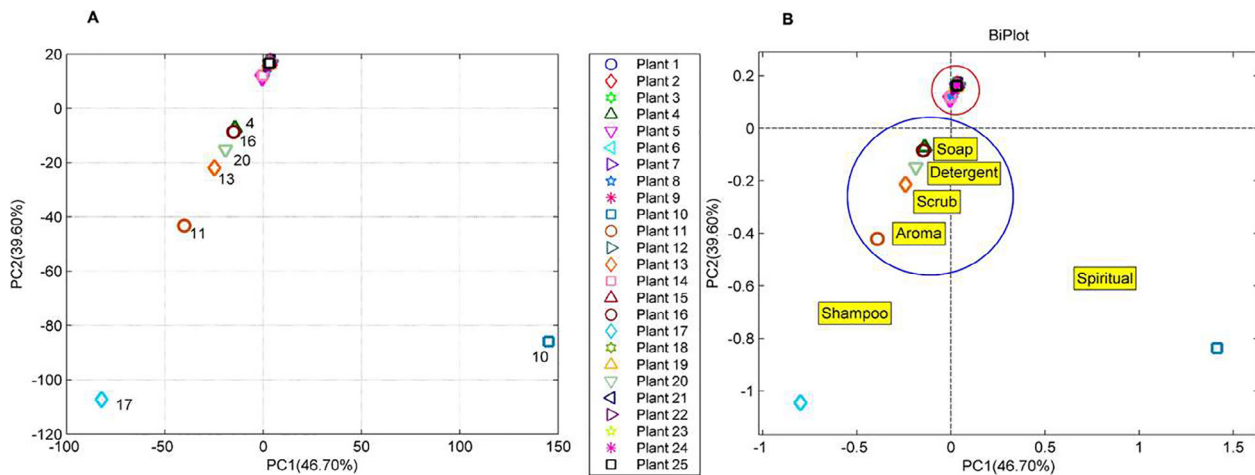


Fig. 4. Biplot acclimations between detergent definitions and shampoo, scrub, detergent, soap, scent and spiritual. Lists of plants are detailed according to the serial numbers listed in Table 1.

A. concinna showed the highest positive presence of phytochemicals (+++). Total saponin content showed significant variations within the plant samples and had the highest content in methanol and water solvents, ranged between 0.17 and 2.66 and 0.15–1.88 mg DE/g extract, respectively. *S. rarak* illustrated the highest amount of saponin content in methanol extract (2.66 mg DE/g extract), followed by *A. concinna* (1.15 mg DE/g extract) and the less was *A. acidum* (0.15 mg DE/g extract) (Fig. 5).

3.6. Detergent plant definition by phytochemicals

From Fig. 6, the different solvents used for chemical extraction affected the content of six chemicals. According to methanol extraction (Fig. 6A), the principal component analysis of the analysed detergent plants showed their degree of correlation with respect to their phytochemicals and surfactant components in methanol extractions. The first principal component depicted 45.45% of the total variation in which *Calamus* sp. and *L. glutinosa* correlated positively with ‘Ter’ and ‘Tan’. ‘Gly’ and ‘Ster’ were found to be solely dominated by *H. riparia* and *A. acidum*. From the PCA analysis the PC2 exhibited 31.66% of variability having positively correlation with Sap. This accounted for higher cleansing properties of *A. concinna* that scored heavily for this particular component. The species *S. rarak* and *A. biflorum* were found to be divorced of any phytochemicals and thus correlated negatively

with the phytochemical components. This might account for their lowest detergent properties and cleansing action.

Fig. 6B shows the performance of each plant according to the chemical contents, extracted by water. Based on the position of *A. biflorum* which located far from the others, might refer that it had ‘Ster’ higher than other plants. In addition, both *Calamus* sp. and *L. glutinosa* also had ‘Alk’ higher than the rests while *S. rarak* and *A. acidum* had ‘Sap’ and ‘Tan’ as well as *H. riparia* but *H. riparia* had higher content of ‘Tan’.

4. Discussion

The loss of local plants and the associated knowledge have generally negative impacts on the local communities who rely on these resources. Factors influences the declining perception of local plant utilisation by indigenous people include, but of course not limited to, the introduction of western medicine, urbanisation, land degradation (Nankaya et al., 2019), modernisation (Siriphon, 2006) and increasing of environmental changes (Turner et al., 2000) as well as the lack of propagation techniques (Nandwani et al., 2008; Wisetkomolmat et al., 2020). In this study, we access the status of the existing knowledge of the 25 Thai local detergent plants. The forest dependent community in the Northern Thai was chosen as they exploit the true relationship between human being and the forest.

Data from the survey agrees with literatures described the common plants used for the purpose of cleansing in Thai culture are butterfly pea, fruit of kaffir lime and rice (Kumar et al., 2012; Pasukamonset et al., 2016). Butterfly pea is also known by several common names including blue pea or anchan in Thai. It is a highly palatable forage legume from the Fabaceae family. In Asia, young shoots, leaves, flowers and tender pods are eaten as vegetable. Due to its attractive blueish flowers they are often crushed and filtered through cloth. The juice is applied on the scalp to promote hair growth (Gomez and Kalamani, 2003; Kumar et al., 2012; Mukherjee et al., 2008). Our result showed that Ma-kruut (*C. hystrix*; Rutaceae) or kaffir lime had the highest of UVs (1.853). Ma-kruut is very common in every household as an ingredient in Asian dishes including those of Thailand, Sri Lanka and Myanmar. The essential oil from the skin of the fruit and juice is used as shampoo to defecate lice in children (Panthong et al., 2013; Subhadrabandhu, 2001). Yabesh et al. (2014) reported high UVs of *C. hystrix* (2.00) which was used by local traditional healers in India for anti-dandruff and hair loss. Also report of Silalahi

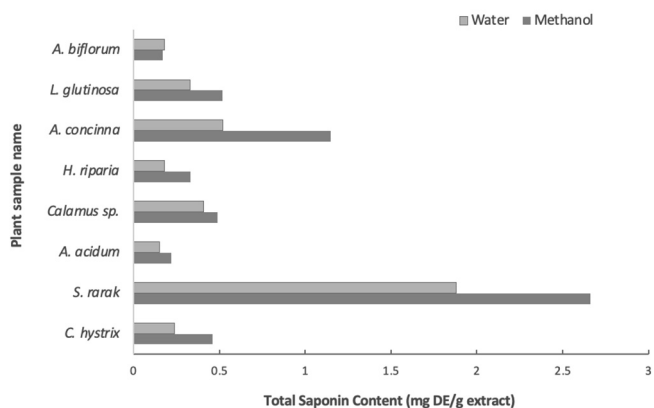


Fig. 5. Total saponin contents in collected plants used in cleansing purposes.

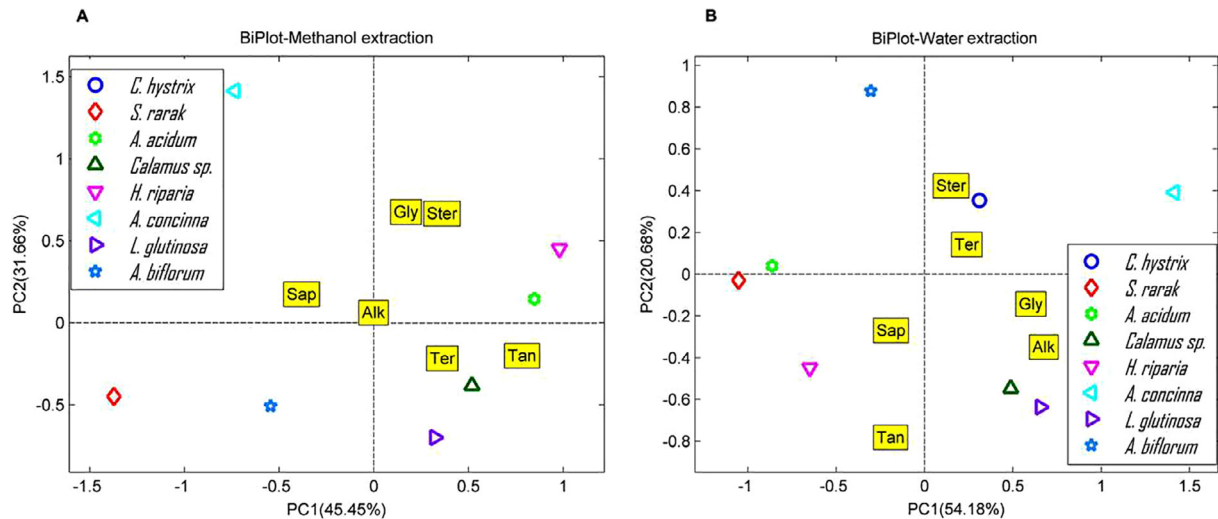


Fig. 6. Biplot acclimations between detergent plants and the chemical contents extracted by methanol and water.

(2019), UVs = 4.08, it was used as steam-bathing materials by the people in Indonesia. In Thailand fresh kafir lime fruits are squeezed and mixed with coconut oil for hair conditioner and to promote hair growth (Kumar et al., 2012). The fruit skin was traditionally used among the Malaysians for shampoo and also the fruit juice is rubbed onto the skin to soften or mixed with bath water (Abirami et al., 2014). Thai people consume rice in every meal and all parts of rice gain are deployed (Chongchorhor and Kabmala, 2017). For the Northern Thai, glutenous rice grains required over-night soaking with clean water before steaming. The by-product of this process enriched with nutrients and good bacteria culture is known for good skin cleanser and shampoo (Marto et al., 2018).

Indigenous people have employed the benefits from the forest environment thereby developed ways of culture and knowledge linked to their environment based on an accumulation of knowledge about forest ecology and ecosystem biodiversity (Siriphon, 2006; Visweswari et al., 2013). Based on plant recognition, utilisation and visibility results in general, plants that are often diverse utilised are tended to be domesticated and therefore are generally found in the villager home gardens such as *C. ternatea*, *C. hystrix* and *O. sativa* which have the highest percentages of citation. Normally, the majority of plant found in many home gardens are edible plants used in many purposes including for food and medicine (Panyadee et al., 2019). More result illustrated that in this forest community, few plant species such as *S. rarak* were used and were not grown or available in the village. This indicates that the villagers had knowledge of plants from areas beyond their territory (Rijal, 2011). Similar with the results of Faruque et al. (2018) found that some species had the highest frequency of citation but not found in the village because those were collected by traditional healers from the wild. The results also illustrated that the community lacked knowledges of some plant species. To this Turner et al. (2000) argued that the knowledge of plants is also culturally exemplified and could reflex vastly to the traditional knowledge of the community. Traditional knowledge of plant uses has accumulated and has been passed on from ancestors to the later generations by spoken word and by life style (Inta et al., 2013).

In other cultural complexes, the selection of wild plants was governed primarily by availability of the plants in the local environment (Pala et al., 2019; Raj et al., 2018). Many ethnic groups rely on wild-collected plants for food and many other purposes from birth to death for examples; some indigenous plants are used

in aroma therapy and as baths, detergents such as fruit of *Dillenia indica* as well as during the spiritual rituals such as *Bambusa* sp., *Nymphaea lotus*, *Gnetum gnemon*, *Rhynchoetechum ellipticum* and *Musa × paradisiaca* (Phangchopi et al., 2014). In previous days, *S. rarak* has been traditionally used as natural detergent, laundry detergent and shampoo by people in many areas of the world. The saponins found in fruits are responsible for detergent properties (Tmáková et al., 2016).

From biometric analyses of detergent plant knowledge in Fig. 3 shown that knowledge of plant uses may not thoroughly distributed with people in all age groups and local people with younger ages appeared to have a less extensive utilisation knowledge of this group of plant (Nandwani et al., 2008; Turner et al., 2000). Our result, however interestingly indicate that *L. glutinosa* has been recognised, visible, and utilised by the younger generations. Therefore, in this particular community, the knowledge of detergent plants is persistent. Even though they had not used them, but they could at least distinguish or experience the uses of these plants in other ways. It is known by Thai people that the mucilaginous leaves of *L. glutinosa* are used in combination with kafir lime and flower of butterfly pea for Thai traditional shampoo (Panyadee et al., 2016; Wisetkomolmat et al., 2019). Gender was also not significantly correlated to knowledge of plant utilisation (Lara Reimers et al., 2019).

In the study of the terms used, we purposed that ‘detergent’ should be defined only for soap, shampoo, scrub, scent and detergent but not for spiritual cleansing. Wisetkomolmat et al. (2019) and Basu et al. (2015) explained that when using plants as detergents, they should be able to remove the outer layer of grease in which the dirt is embedded. For scientific term, detergents are amphipathic molecules that exhibit unique properties in aqueous solutions, in which they spontaneously form spherical micellar structures in addition to lowering the surface tension of their solutions (Bhat et al., 2011; Niven Jr, 1955; Seddon et al., 2004). Soap, in another hand, is the major product of saponification between triglyceride and lye solution (Atolani et al., 2016) while, foam is formed in aqueous solution through the dispersion of air bubbles in water surface stabilised by the surface-active agents such as surfactants, proteins, polymers or macromolecule (Chen et al., 2017; Tadros, 2006).

Plants contains phytochemicals that are generally bioactive. Among those, the alkaloids are substances produced by plants to protect themselves against the aggression from other organisms

and are medicinal proven to be beneficial for pain relief (Debnath et al., 2018). Glycosides and phytosteroids are extracted from plants include some pharmacologically important products such as cardiac aglycones (Goncharov et al., 2016; Heftmann, 1975). Tannins are a class of complex biomolecules of polyphenolic nature synthesised by a large variety of plants, in which they are used as mordents, medical astringents, antipredation or pesticide agents (Hassan et al., 2015; Izawa et al., 2010; Patachia and Croitoru, 2016). Saponins are amphipathic glycosides grouped having one or more hydrophilic glycoside moieties combined with a lipophilic triterpene derivative. These compounds are traditionally used as natural surfactant (Böttcher and Drusch, 2016; Goncharov et al., 2016; Kregiel et al., 2017), called bio-based surfactant (Tmáková et al., 2016; Wisetkomolmat et al., 2020). Due to the presence of a lipid-soluble aglycone and water-soluble sugar chain, natural saponins own surfactant properties that are foam formation (with liquid-gaseous phases) (Hassan et al., 2015), an emulsifier effect (with liquid-liquid phases) and dispersion abilities (with liquid-solid phases). In the aqueous solution, saponin molecules align themselves vertically on the surface with their hydrophobic ends faced away from the water (Almutairi and Ali, 2015). This has the effect of reducing the surface tension of the water, causing bubbles or foamability (Böttcher and Drusch, 2016; Kregiel et al., 2017).

The results of phytochemical screening showed that water extract of *L. glutinosa* leaf had the high variety of secondary metabolites. The total saponin content, *S. rarak* showed the highest amount of saponin content followed by *A. concinna* and *L. glutinosa*. This is in agreement with the reports of Pradeepa et al. (2013), Gulzar et al. (2015) and Mandal et al. (2000) who advised that the extract from leaves of *L. glutinosa* contained alkaloids, steroids, flavonoids, terpenoids, tannins glycosides and saponins. The results of Devi and Meera (2010) suggested that methanolic extracts of *L. glutinosa* contained high saponin and alkaloid content that had significant antioxidant, anti-inflammatory, antispasmodic, emollient and possessed wound healing and antibacterial activity. Pradeepa et al. (2013) added that the significant effect of the phytochemical extracts of *L. glutinosa* is due to the presence of a single active constituent in higher levels or due to the combined effect of more than one phytoconstituents.

5. Conclusion

In conclusion, traditional ecologically knowledge is rapidly declined, owing to cultural change and urbanisation. The present study showed that forest dependent community was vitally important group of people to reserve the knowledge of indigenous plant utilisation. From the preliminary investigation, the use of chemometric combined with ethno-informatic data had led to the understanding of the relationships between the phytochemicals and plant usage as cleansing purposes. The research outcome could support the awareness regarding the role of the community to conserve, protect and promote the dissemination of knowledge for local Thai detergent plants.

CRedit authorship contribution statement

Jiratchaya Wisetkomolmat: Methodology, Formal analysis, Investigation, Data curation, Writing - original draft, Project administration. **Angkhana Inta:** Methodology, Writing - review & editing, Supervision. **Chanida Krongchai:** Software, Data curation. **Sila Kittiwachana:** Methodology, Software, Writing - review & editing, Supervision. **Kittisak Jantanasakulwong:** Funding acquisition. **Pornchai Rachtanapun:** Funding acquisition. **Sarana Rose**

Sommano: Conceptualization, Methodology, Data curation, Writing - review & editing, Supervision, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Further Reading

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