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Ethnobotany of Zingiberaceae in Mae Hong Son, Northern Thailand

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Abstract. *Inta A, Trisonthi C, Pongamornkul W, Panyadee P. 2023. Ethnobotany of Zingiberaceae in Mae Hong Son, Northern Thailand. Biodiversitas 24: 2114-2124.* Zingiberaceae (ginger family) is one of the most important used plant families in Thailand. In this study, the uses of ginger species among the ethnic groups in Mae Hong Son province, northern Thailand, was investigated, which aims to answer these questions: how much diversity of ginger species is being used by the ethnicities in northern Thailand; which use categories are a most important use of ginger species? and which species or genera are the most important? The qualitative and quantitative ethnobotanical investigations were conducted with informants through semi-structured interviewing during a walk-in-the-woods in the forest around the villages and home gardens. The importance of each ginger species was compared using the ethnobotanical indices, including use-report (UR), cultural importance index (CI), fidelity level (FL), and informant agreement ratio (IAR). Therefore, 1, 218 use reports of local Zingiberaceae were recorded, belonging to six use categories; 33 native ginger species of 9 genera were found. Food and medicine are the two most dominant use categories, with 572 and 446 use reports, respectively. According to the number of UR and CI, the most important local Zingiberaceae species were *Zingiber purpureum*, *Curcuma longa*, *Alpinia galanga*, *Z. officinale*, *Z. ottensii*, *Z. rubens* and *Amomum siamense*, respectively. About half of the ethnomedicinal ginger species found in this study were first reported for their medicinal properties.

Keywords: Diversity, ginger family, local wisdom, non-timber product, traditional knowledge

INTRODUCTION

Northern Thailand is the home of more than 20 ethnicities (Junsongduang et al. 2014) who have lived harmoniously with the surrounding natural resources since ancient times. They have adapted to and utilized the nature around them, resulting in a great diversity of ethnobotanical knowledge. Therefore, about 40% of ethnobotanical studies in Thailand were conducted in this region (Phumthum et al. 2018), where more than 1,700 used species were recorded for their utilization (Pongamornkul et al. 2017). Among these, Zingiberaceae was cited and noted as one of northern Thailand's most used family of used plants. Plants in Zingiberaceae were frequently cited as one of the most used species among different ethnicities in northern Thailand (Pongamornkul et al. 2017; Phumthum and Balslev 2020; Numpulsuksant et al. 2021; Panyadee et al. 2023). They were used by many ethnicities, especially for treating digestive system disorders (Tangjitman et al. 2015; Numpulsuksant et al. 2021; Saensouk and Saensouk 2021; Ragsasilpt et al. 2022).

Zingiberaceae is an aromatic, perennial, and rhizomatous herb comprised of about 50 genera and 1, 600 species (Larsen and Larsen 2006). Plants in this family have played important roles in the daily life and the economy of many communities, especially those from Southeast Asia and India. For example, in Thailand, about 300 species from 26 genera were estimated (Larsen and Larsen 2006), of which at least one-quarter are used as ethnomedicine (Phumthum and Balslev 2020). In addition, Thai people have used plants in Zingiberaceae since ancient times to treat various health conditions, especially ones related to the digestive system (Numpulsuksant et al. 2021; Phumthum and Balslev 2020; Ragsasilpt et al. 2022; Tangjitman et al. 2015).

Zingiberaceae gained the most consideration in ethnobotanical studies among many taxonomic groups of plants in Thailand. Many ethnobotanical studies in Thailand have focused only on Zingiberaceae. However, most were conducted in northeastern Thailand (i.e., Khamtang et al. 2014; Saensouk et al. 2016; Saensouk and Saensouk 2018; Numpulsuksant et al. 2021; Saensouk and Saensouk 2021; Ragsasilpt et al. 2022). Therefore, 67 species were recorded for their uses, most of which were used as medicine, ornamental plants, or food. Southern Thailand has the highest diversity of Zingiberaceae because of the suitability of climate and landscape (Nontasit et al. 2015); 42 species were reported for their usage from this area (Khiankhan 2017). These studies agree that Zingiberaceae is mainly used as food or medicine. A cross-region study showed that 58 species (46 spp. were identified to species level) were used as medicine, mostly to treat digestive system disorders, especially flatulence (Tangjitman et al. 2015; Saensouk and Saensouk 2021; Ragsasilpt et al. 2022). A comprehensive review of the ginger species used in ethnomedicine in Thailand has revealed that 76 species were used to treat various health conditions (Phumthum and Balslev 2020). However, no such study focused on the ethnic groups living in northern Thailand.

In this study, we present the diversity of ginger species associated with traditional knowledge used in the daily life of the indigenous people in northern Thailand. In particular, we aim to answer these questions: (i) How much diversity of ginger species is used by the ethnicities in northern Thailand? (ii) Which use categories are most common for ginger species? and (iii) Which species or genera are the most important?

MATERIALS AND METHODS

Study area

The study was conducted in nine villages of six ethnic groups in Mae Hong Son province, northern Thailand, including a village of Lahu, Lawa, Lisu, and Pwo people; two villages of Shan people; and three villages of Skaw (Table 1; Figure 1). The elevations of the studied villages ranged from 500-1, 000 meters above sea level. Their main crops were highland and paddy rice. Vegetables, another important crop, were cultivated in the highland rice fields, home gardens, or gathered from the nearby forests (Figure 2). Since the villages were far from the public health center, the villagers still relied on medicinal plants for their basic ailments such as fever, cough, diarrhea, and muscular pain. In addition, in the rainy season, the villages were almost un-accessibility. Moreover, most villagers in the studied villages cannot speak Thai. Therefore, contact with outside urban communities was rare. According to these reasons, the villagers still lived a traditional lifestyle, and local plants were still extensively used as traditional medicine.

Ethnobotanical data gathering

In this study, we used two combination methods—walk-to-the-wood and semi-structured interviews. Firstly, qualitative ethnobotanical investigations were conducted in each village. Then, one or two key informants were selected. These were local healers or those with good plant knowledge, which other villagers approved. Therefore, the key informants were interviewed during a walk-in-the-woods in the forest around the village and home gardens. They were asked about the traditional use of ginger species encountered during the fieldwork. The photographs of each species were taken, and the samples were collected for future identification. For some species found only in sterile conditions, the living samples would be collected and planted in the Queen Sirikit Botanic Garden nursery, Chiang Mai, Thailand. The investigations were carried out during 2019-2021. Each village was visited 3-5 times during the study period.

Finally, the key informants were asked to confirm the vernacular name of each species from the photographs and dried specimens before the beginning of semi-structured interviews.

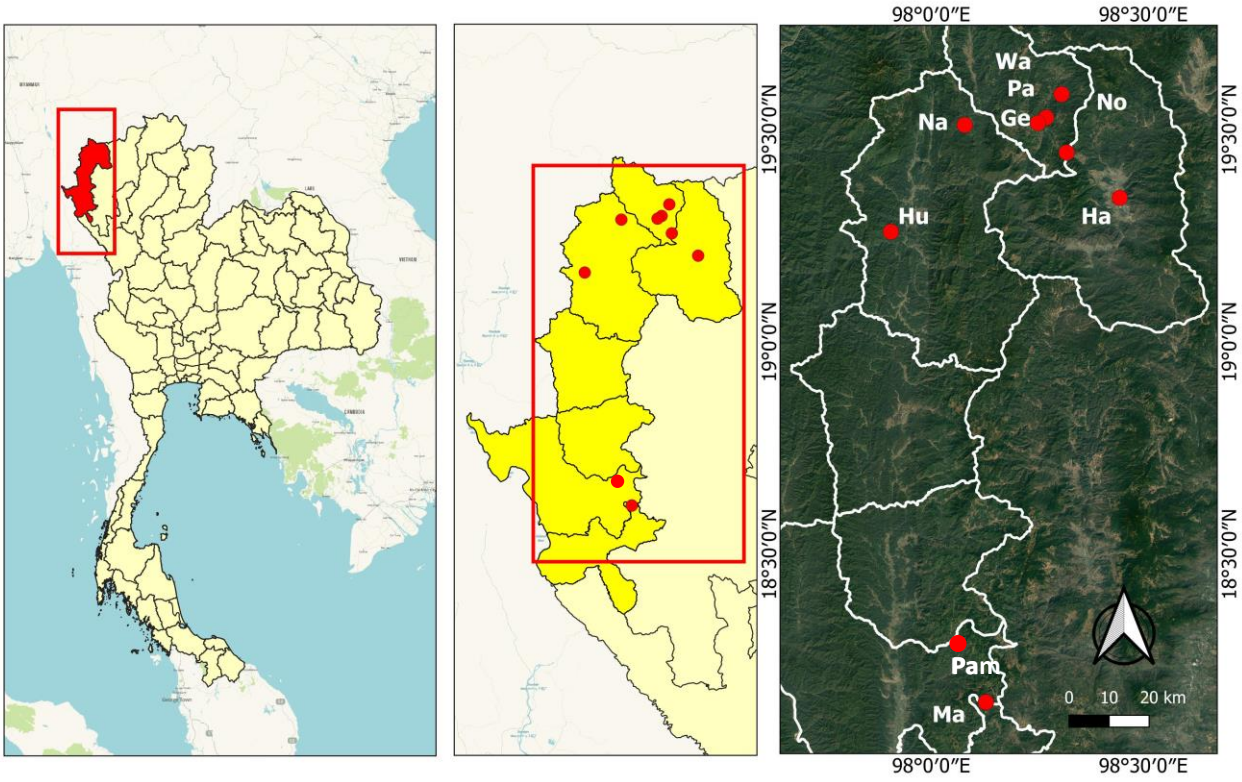

Figure 1. Location of Mae Hong Son province, northern Thailand, indicating the nine studied villages (Wa: Wana Luang, No: Nong Thong, Ma: Mae Lai Nue, Pam: PamPa, Ge: Gew Lom, Hu: Huai Sue Thao, Pa: Pa Pae, Na: Nam Gud, Ha: Huai Sai Khow)

Figure 2. Studied areas (A-F) included the arable land (paddy rice field) and the nearby forest near the village (A), home gardens (B), and Zingiberaceae species which were cultivated in home gardens (C-E). The inflorescences of *Curcuma angustifolia*, along with other vegetables, were used for food (F)

Table 1. Basic information about the studied villages

Ethnic group	Village	Location coordinates	Elevation (m asl.)	Vegetation type
Lahu (LA)	Wana Luang	19°31'43 .24" N 98°16'16.36" E	300-800	Deciduous forest
Lawa (LW)	Pa Pae	18° 9'4.93" N 98° 7'45.22" E	700-800	Deciduous and evergreen forest
Lisu (Li)	Nong Thong	19°30'57.28" N 98°15'5.99" E	300-800	Deciduous forest
Pwo Karen (PW)	Huai Sue Thao	19°15'34.18" N 97°54'18.59" E	300-400	Deciduous forest
Skaw Karen (SK)	Gew Lom	19°26'46.28"N 98°19'10.23"E	1100-1200	Evergreen forest
Skaw Karen (SK)	Mae Lai Nue	18° 9'4.93" N 98° 7'45.22" E	900-1100	Evergreen forest
Skaw Karen (SK)	Pam	19°35'1.45" N 98°18'27.51" E	500-800	Deciduous forest
Shan (SH)	Nam Gud	19°30'40.59" N 98° 4'45.58" E	500-600	Deciduous forest
Shan (SH)	Huai Sai Khow	19°20'22.80" N 98°26'41.58" E	400-600	Deciduous forest

Semi-structured interviews were conducted with representatives of 34 informants who had experienced traditional knowledge, e.g., local healers, experienced housewives, or local hunters. The informants were aged between 41-82 years. Each key informant would be independently interviewed about traditional uses of local Zingiberaceae species by showing photos and vouchers from the walk-to-the-wood investigation. Vernacular names were mentioned if necessary. The main questions included parts of usage, preparation methods, and administration route. The interviews were carried out in the local language through local translators.

Identification and categorization

The voucher specimens were collected and identified to species level at the Laboratory of Ethnobotany and Northern Thai Flora, Chiang Mai University, and the herbarium of Queen Sirikit Botanic Garden (QBG), using specific literature of Zingiberaceae, for example, Gingers of Thailand (Larsen and Larsen 2006). Plant specimens and living collections were deposited at QBG. The use and ailment categories followed the Economic Botany Data Collection Standard (Cook 1995) with a supplement from Gruca et al. (2014).

Data analysis

Use information was collected in terms of *use report* (UR), a mention of the use of a species by an informant (Kufer et al. 2005). Each plant used species was calculated by the *cultural importance index* (CI), an index measuring the range of categories (Leonti 2022). The maximum of the CI was equal to the total number of different use categories, which in this study was six, i.e., food, food additive, medicine, social use, material, and ornamental. Any local Zingiberaceae species in which CI reached the maximum value are used for the application by all informants (Leonti 2022). The *fidelity level* (FL) was calculated to determine the most preferred local Zingiberaceae species used in each use category (Friedman et al. 1986; Al-Robai et al. 2022). The *informant agreement ratio* (IAR) *was* used to measure the agreement between informants concerning what local Zingiberaceae species are used for a specific symptom. The IAR ranges from 0 to 1. A value of 1 indicates that informants only use a taxon in a specific symptom, thus inferring a high degree of consensus and a well-defined local medicinal Zingiberaceae species (Heinrich et al. 1998; Chaachouay et al. 2019). IAR could also indicate which ailments are most frequently encountered and most frequently treated by ginger species. In other words, the diseases that Zingiberaceae are best treated.

RESULTS AND DISCUSSION

Diversity of ginger species identified in the study areas

Although the study covers only a small portion of northern Thailand, 33 species from 9 genera were identified from local communities in Mae Hong Son province (Table 2). The genus *Zingiber* had the highest number of species (9 spp.), followed by the genus *Curcuma* (7 spp.). A total of 1,218 use reports were documented from semi-structured interviews with 34 key informants. They were classified into six categories, i.e., food, food additives, material, medicines, ornamental plants, and social uses (Figure 3). Medicine and food were the two largest categories, contributing to more than 70% of total use reports and including all species.

Food additives or spices are another important categories that include many species, e.g., *Alpinia galanga, Curcuma longa,* and *Zingiber officinale.* Many species with beautiful leaves or inflorescences were also cultivated as ornamental plants, e.g., *Boesenbergia kingii, Curcuma amada, Hedychium flavescens, H. coronarium, Kaempferia galanga, K. roscoeana,* and *Zingiber zerumbet.* The local people believed some species possess supernatural abilities, e.g., *Boesenbergia kingii, Curcuma zanthorrhiza, Kaempferia galanga,* and *K. parviflora*. Therefore, they were planted in home gardens to protect the residents from black magic. Turmeric (*Curcuma longa*) is the only species categorized in the material category used; its rhizomes were used as a dye for the yellow color.

The number of used categories for each ginger species ranged from 1-4 (Table 2). Eight species were used only in one category or had a 100% fidelity level (FL), including *Amomum dealbatum* (food), *A. siamense* (food), *Curcuma candida* (food), *C. rubescens* (medicine), *C. rubrobracteata* (food), *Globba winitii* (medicine), *Hedychium coccineum* (medicine), and *Hedychium coccineum* (medicine). The other species could be used in at least two categories; however, their FL was unequally distributed across the different categories. For example, the uses of galangal (*Alpinia galanga*) were classified into three categories, i.e., food, food additives, and medicines. However, ~80% belonged to food categories such as fresh vegetables (Table 2). Turmeric (*Curcuma longa*) is another multipurpose species, and its uses were classified into four categories, i.e., food (20.4%), food additives (25.4%), material (as dye material, 3.4%), and medicine (50.8%); with unequal FL.

According to semi-structured interview data, rhizomes are most used by the informants; 27 species (out of 33) accounted for 40% of the total use report. Other important useful parts were flowers and pseudostems, which accounted for 19.4% and 14.8%, respectively, of total URs (Figure 4). Both home gardens and nearby forests were important sources of ginger species; 21 species could be found in home gardens as in the forest. In addition, nine species were reported from home garden and forest, including *Alpinia galanga, Amomum dealbatum, Amomum siamense, Boesenbergia rotunda, Curcuma amada, Globba winitii, Wurfbainia schmidtii, Zingiber citriodorum,* and *Z. parishii.*

Medicinal ginger species

The local communities of Mae Hong Son province use 26 ginger species to treat 27 ailments which could be classified into 14 categories (Table 2 and Table 3). The number of species used to treat a single symptom ranged from 12 to 1 (Table 3). The ailment with the largest species used is muscular pain (12), a single symptom in the muscular-skeletal system disorder category. Other large species used are: carminative (9), stomachache (8), and gastritis (6), which are classified as digestive system disorders (Table 3). However, regarding use reports, carminative is the most important use of ginger species, with 70 reports, followed by post-obstetric use (54) and muscular pain (46). Therefore, the digestive system disorder is the largest disorder category in terms of both use-report and number of species. According to the number of use reports, the second largest system disorder is pregnancy-related disorder, although there were only four species in this category.

The informant agreement ratio (IAR) was used for the agreement between informants concerning a specific ailment. In addition, the system disorders with the maximum IAR_A were circulatory system disorder, genitourinary system disorder, mental disorder, and nutritional disorder. However, their use report (N_{ur}) and the number of species (N_t) were small (Table 3). The system disorders with high scores for N_{ur} and IAR were digestive system disorder and pregnancy/birth/puerperium disorder. The IAR of digestive system disorder is 0.93 with 162 URs, the highest value. The pregnancy/birth/puerperium disorder category also had high IAR, equaling the digestive system disorder category, but with lower use reports and several species (Table 3).

Table 2. Traditional uses of local ginger species by ethnic groups in northern Thailand

Botanical name [voucher no.]	Vernacular name [ethnic groups]	Plant sources	CI	Category	UR	FL (%)	Plant part*: Application [ethnic group]
Amomum dealbatum Roxb. [WP7141]	kuk [LA], pho sa [SK], kad sang [LW], poo zae [PW], heo kuk [SH]	Homegarden, Forest	1.4	Food	48	100.0	fl, fr, st, rh: vegetable [LA, SK, LW, PW, SH]
				Medicine	4	66.7	rh: dizziness [LA]
Amomum siamense Craib [WP7148]	pho ka [SK], kad sang [LW], Glaong pong lae [PW], heo ka [SH]	Homegarden, Forest	1.6	Food	56	100.0	fl, fr, se, st: vegetable [SK, LW, PW, SH] fr: tea [SH]
Alpinia galanga (L.) Willd. [WP3504]	he chu pi [LA], me pook [LI], se ae che [SK], sa ker bae [LW], ang chai [PO], heo kha [SH]	Home garden, Forest	3.3	Food	94	83.9	fl, fr, st, rh: vegetable [LA, LI, SK, LW, PW, SH]
				Medicine	16	14.3	rh: dizziness [SH], muscular pain [LI], food poisoning [LA], le: vermifuge [SH]
				Food additives	2	1.8	rh: mix with a starter for fermenting alcoholic beverage [LI]
Alpinia malaccensis (Burm.f.) Roscoe [WP4607]	- [LA], to poig [LW], po ker [SK], me tam ma [LI]	Forest	0.9	Food	22	68.8	fl, fr, st : vegetable [LA, LW, SK]
				Medicine	10	31.3	rh: sauna [LA, LI], antitussive [SK]
Alpinia nigra (Gaertn.) B.L.Burtt [WP7181]	se ae che me [SK], - [LI], kae chu pi hae pue kue [LA], heo kha tern [SH]	Forest	0.6	Food	20	90.9	fl, le, st, rh: vegetable [SK]
				Medicine	2	9.1	rh: dizziness [SH], muscular pain [LI], food poisoning [LA], le: vermifuge [SH]
Alpinia roxburghii Sweet [WP6504]	po ker me [SK], poing [LW]	Forest	0.2	Medicine	2	25.0	rh : antitussive [SK]
				Food	6	75.0	fl: vegetable [LW, SK]
Boesenbergia kingii Mood & L.M.Prince [BGO96120]	pa tee ji [SK], - [LI], po ta ro [PW]	Forest	1.1	Medicine	4	11.1	rh: food poisoning [SK], stomachache [SK]
				Food	28	77.8	fl, le, st, rh: vegetable [LI, SK, PW]
				Social uses	2	5.6	wh: plant in home garden to protect from black magic [SK]
				Ornamental	2	5.6	wh: ornamental [LI]
Boesenbergia rotunda (L.) Mansf. [WP3221]	po chor lor [SK], heo [SH], ka chai [LA, LI, PW]	Home garden, Forest	1.6	Medicine	22	39.3	rh: carminative [SK, SH], gastritis [SK], neurotrophic [SH]
				Food	34	60.7	fr, st, rh: vegetable [LA, LI, SK, PW, SH]
Curcuma amada Rob. [WP7098]	mok aoi tern [SH]	Home garden, Forest	0.4	Food	12	85.7	infl, st: vegetable [SH]
				Ornamental	2	14.3	wh: ornamental [SH]
Curcuma angustifolia Roxb. [QBG11030]	po ta klee [SK], me pu [LI], aoi [LW], mok aoi [PW, SH]	Forest	1.1	Medicine	6	15.8	rh: intumesce [SK], itchy [SK]
				Food	32	84.2	fl: vegetable [LI, LW, SK, PW, SH]
Curcuma candida (Wall.) Techapr.& Skornick. [WP2004]	mok din [SH, PW]	Forest	0.3	Food	10	100.0	infl, st: vegetable [SH, PW]
Curcuma longa L. [WP2004]	khao min [SH], kha min [LI], se yor [SK], sa kliang [LW], me chi [LA], yae bang [PW]	Home garden	3.5	Medicine	60	50.8	rh: diarrhea [SH], gastritis [LI, SK], carminative [LW, SH], insect bites [SK, LW, SH], compress [LA], antitussive [SK], wound [SK, LW], constipated [SH], itchy [SK, SH], toothache [SK], anti-inflammatory [SK]
				Food	24	20.4	infl, le, rh: vegetable [LI, LW, SK, SH]
				Food additives	30	25.4	rh: spices [LW, SK, SH, PW]
				Material	4	3.4	rh: pigment [LW]
Curcuma rubescens Roxb. [QBG93475]	po ker [SK], wan kae [SH]	Homegarden	0.8	Medicine	26	100.0	rh: stomachache [SK], gastritis [SK], wound [SH], food poisoning [SK]
Curcuma rubrobracteata Skornickova, Sabu & Prasanthk [WP4429]	wan [LW]	Forest	0.1	Food	4	100.0	infl: vegetable [LW]

Curcuma zanthorrhiza Roxb. [WP10002]	po pa do [SK], - [PW], wan [SH]	Home garden	1.0	Medicine	24	70.6	rh: stomachache [SK], gastritis [SK], carminative [PW], post obstetric [SH], dizziness [SH], insect bites [PW], compress [SH]
				Food	8	23.5	le, rh: vegetable [PW, SH]
				Social uses	2	5.9	rh: protect from black magic [SK]
Etlingera linguiformis (Roxb.) R.M.Sm. [WP6613]	per ker [SK], heo tern [SH]	Forest	0.4	Medicine	8	66.7	rh: post obstetric, compress, fever [SK]
				Food	4	33.3	st: vegetable [SH]
Globba winitii C.H.Wright [WP7182]	wan khow pan sa [SH]	Home garden, Forest	0.1	Medicine	4	100.0	rh: follicular pharyngitis [SH]
Hedychium flavescens Carey ex Roscoe [WP10003]	mok heo kham [SH], po ner mu [SK]	Home garden	0.6	Medicine	6	27.25	rh: itchy [SH]
				Social uses	6	27.25	infl: worship [SH]
				Ornamental	10	45.5	wh: ornamental plants [SK, SH]
Hedychium coccineum Buch.-Ham. ex Sm. [WP324]	- [PW]	Forest	0.1	Medicine	2	100.0	rh: itchy [LA], compress [LA]
Hedychium coronarium J.Koenig [WP1948]	mok heo ngen [SH], - [LI]	Homegarden	0.5	Medicine	6	33.3	rh: itchy [SH]
				Social uses	6	33.3	infl: worship [SH]
				Food	2	11.1	st: vegetable [LI]
				Ornamental	4	22.2	wh: ornamental plants [SH]
Kaempferia galanga L. [QBG62540]	- [LW, SK, LI, SK, SH]	Homegarden	1.1	Medicine	18	50.0	rh: burns [LW], muscular pain [SK], menstruation [LI]
				Social uses	6	16.7	wh: plant for protection from black magic [SK] rh: chewing with betel nut [SH]
				Ornamental	12	33.3	wh: ornamental plants [SK, SH]
Kaempferia parviflora Wall. ex Baker [QBG92737]	kra chay dam [LA, LI, SH], po sor lor soo [SK]	Homegarden	1.1	Medicine	34	89.5	rh: carminative [LA, LI], stomachache [SH], hypertension [LI], tonic [LI, SK]
				Social uses	4	10.5	wh: protect from black magic [SK]
Kaempferia roscoeana Wall. [WP2700]	- [LI, SK, SH]	H	0.4	Medicine	4	33.3	rh: tonic [LI]
				Ornamental	8	66.7	wh: ornamental plants [SK, SH]
Wurfbainia schmidtii (K.Schum.) Škorničk. & A.D.Poulsen [WP10001]	ja ku ma sue [LI], - [LA]	Home garden, Forest	0.2	Food	2	33.3	le: vegetable [LI]
Zingiber chantaranothaii Tribuon & K.Larsen [WP7099]	- [LA], pe la he [SK]	Forest	0.5	Medicine	4	25.0	rh: compress [LA]
				Food	12	75.0	infl: vegetable [SK]
Zingiber citriodorum Theilade & Mood [WP10004]	- [LI, SK, SH]	Home garden, Forest	0.6	Food	22	100.0	infl, rh: vegetable [LI, SK, SH]
Zingiber officinale Roscoe [WP10005]	jiang [LI], si ae [SK], sa kuen [LW], khing [SH], ang [PW], chu pi [LA]	Home garden	2.4	Medicine	30	36.6	rh: muscular pain [LI], antitussive [SK, LW], fever [SH], carminative [SH], galactic [PW]
				Food additives	18	22.0	rh: spices [LA, LI, SK, LW, PW, SH]
				Food	32	39.0	infl, le, st, rh: vegetable [LA, LI, SK, LW, PW, SH]
				Food additives	2	2.4	rh: mix with a starter for fermenting alcoholic beverage [LI]
Zingiber ottensii Valeton [WP2001]	phu loei dam [LI], pa lauy long [LW], pe kho xu [SK], min sa lang lam [SH]	Home garden	2.0	Medicine	48	70.6	rh: carminative [LI, LW, SK], post obstetric [LI, SK, SH], compress [LI, SH], klysma [LW], stomachache [SK], gastritis [SK]
				Food	20	29.4	infl, st: vegetable [LI, LW, SK]
Zingiber parishii Hook. f. [WP4359]	- [LI], pe mee [SK]	Home garden, Forest	0.2	Social uses	2	33.3	infl: worship [LI]
				Food	4	66.7	infl: vegetable [SK]

Zingiber purpureum Roscoe [WP4286]	ya pu loei [LA], pu loei [LI], pe kho [SK], sa kliang [LW], per loei [PW], min sa lang [SH]	Home garden	3.7	Medicine	82	65.1	rh, le: carminative [LA, SK, LW], laxative [LI, SK], post obstetric [LI, LW, SK, PW, SH], compress [LI, SH], klysma [LW], dizziness [PW], diarrhea [SK], stomachache [SK], gastritis [SK, PW], follicular pharyngitis [SH]
				Food	40	31.7	infl, rh, st: vegetable [LI, SK, LW, PW, SH]
				Social uses	4	3.2	st: exorcism [LW]
Zingiber rubens Roxb. [WP7100, WP4288]	mak ee [SH], ma yi [SK], me jue [LI], - [LW, PW]	Forest	1.7	Medicine	8	13.8	infr: carminative [SH], stomachache [SK]
				Food	50	86.2	infr, st: vegetable [LI, LW, SK, PW, SH]
Zingiber tenuiscapus Triboun & K.Larsen [WP10006]	pe kho mee [SK]	Forest	0.2	Medicine	4	50.0	rh: stomachache [SK]
				Food	4	50.0	rh: vegetable [SK]
Zingiber zerumbet (L.) Roscoe ex Sm. [WP4287]	me [LI]	Homegarden	0.1	Medicine	2	50.0	rh: carminative [LA]
				Ornamental	2	50.0	wh: ornamental plants [LI]

Note: *plant part: fl: flower, fr: fruit, st: pseudostem, rh: rhizome, se: seed, le: leaves, wh: whole plant

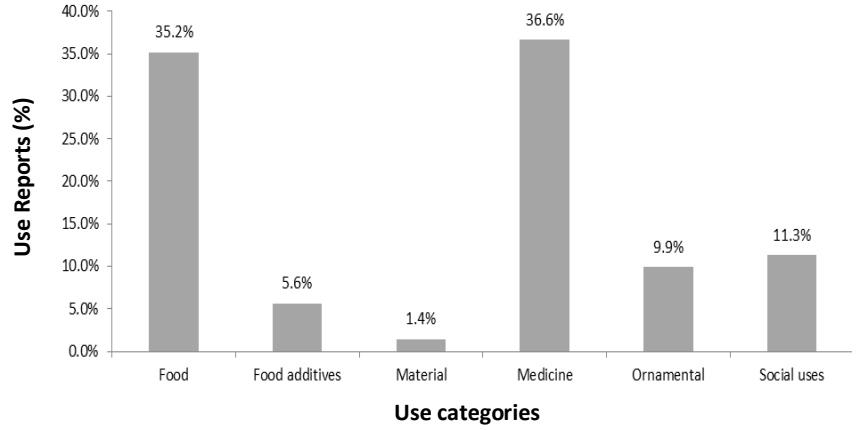

Figure 3. Percentage of Use Reports from local Zingiberaceae species recorded in northern Thailand in different use categories

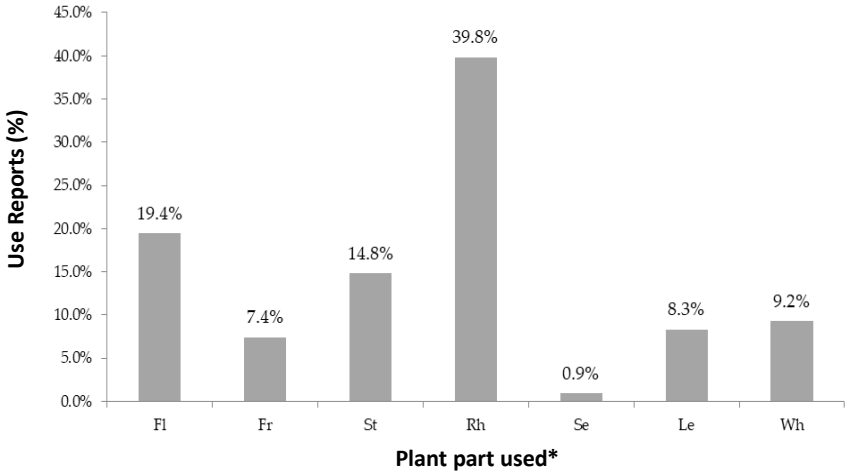

Figure 4. Percentage of Use Reports from local Zingiberaceae species recorded in northern Thailand in different plant parts used (Plant part used* fl: flower, fr: fruit, st: pseudostem, rh: rhizome, se: seed, le: leaves, wh: whole plant)

Important genera and species

The genus *Zingiber*, *Curcuma*, and *Alpinia* were the most important, respectively, according to their number of use reports and species. These genera were used mostly as vegetables or medicinal plants. More than 90% of *Zingiber*'s URs were classified as food or medicine with similar proportions (47% vs. 46%, respectively). However, the genus *Curcuma* was mostly used as medicine (48% of URs), and more than 80% of URs genus *Alpinia* were classified as food. On the other hand, the genus *Globba* had the lowest URs, and only one species was determined, which was *G. winitii.*

According to their cultural importance, the three most important species included *Zingiber purpureum, Curcuma longa,* and *Alpinia galanga*. The cultural indices (CI) of these species are greater than three. This implies these species were used, on average, at least three use categories by each informant. For example, *Curcuma longa* was generally used as medicine; however, it was also used as food and food additives too. Furthermore, four species had the lowest CI, including *Curcuma rubrobracteata, Globba winitii*, *H. coccineum*, and *Zingiber zerumbet.* These species were mostly used as medicine except *C. rubrobracteata*, which inflorescences were eaten as a vegetable.

Discussion

Although this study covers only a small part of Thailand, the data have demonstrated that the traditional knowledge of local ginger species is still diverse and plays crucial roles in local people's daily life. This study has identified 33 species of Zingiberaceae with more than a thousand use reports. That implies a treasure of biological resources achievable for communities' subsistence. Most ginger species identified in this study were used mostly as food or medicines. These use categories contain high numbers of species richness and use-report. This result agreed with previous ethnobotanical studies of Zingiberaceae in northeastern and southern Thailand (Khamtang et al. 2014; Nontasit et al. 2015; Saensouk et al. 2016; Khiankhan 2017; Saensouk and Saensouk, 2018; Numpulsuksant et al. 2021; Saensouk and Saensouk 2021; Ragsasilpt et al. 2022).

Table 3. The information on local medicinal Zingiberaceae species used in different system disorders

System disorders (A)	Symptoms (B)	UR	Local Zingiberaceae species	IAR_B	IAR_A
1. Circulatory System Disorder	Hypertension	2	1. *Kaempferia parviflora*	1.0	**1.00**
2. Defined Symptom	Dizziness	16	1. *Alpinia galanga*	0.7	**0.70**
			2. *Alpinia nigra*		
			3. *Curcuma zanthorrhiza*		
			4. *Wurfbainia schmidtii*		
			5. *Zingiber purpureum*		
3. Digestive System Disorder	Klysma	8	1. *Zingiber purpureum*	0.9	**0.93**
			2. *Zingiber ottensii*		
	Stomachache	26	1. *Boesenbergia kingii*	0.7	
			2. *Curcuma zanthorrhiza*		
			3. *Curcuma rubescens*		
			4. *Kaempferia parviflora*		
			5. *Zingiber purpureum*		
			6. *Zingiber ottensii*		
			7. *Zingiber tenuiscapus*		
			8. *Zingiber rubens*		
	Toothache	4	1. *Curcuma longa*	1.0	
	Carminative	70	1. *Boesenbergia rotunda*	0.9	
			2. *Curcuma zanthorrhiza*		
			3. *Curcuma longa*		
			4. *Kaempferia parviflora*		
			5. *Zingiber purpureum*		
			6. *Zingiber officinale*		
			7. *Zingiber ottensii*		
			8. *Zingiber zerumbet*		
			9. *Zingiber rubens*		
	Constipated	6	1. *Curcuma longa*	1.0	
	Diarrhea	10	1. *Curcuma longa*	0.9	
			2. *Zingiber purpureum*		
	Laxative	4	1. *Zingiber purpureum*	1.0	
	Gastritis	20	1. *Boesenbergia rotunda*	0.7	
			2. *Curcuma zanthorrhiza*		
			3. *Curcuma longa*		
			4. *Curcuma rubescens*		
			5. *Zingiber purpureum*		
			6. *Zingiber ottensii*		
	food poisoning	14	1. *Alpinia galanga*	0.8	
			2. *Alpinia nigra*		
			3. *Boesenbergia kingii*		
			4. *Curcuma rubescens*		
4. Genitourinary System Disorder	Menstruation	2	1. *Kaempferia galanga*	1.0	**1.00**
5. Infections/Infestations	Fever	10	1. *Etlingera linguiformis*	0.9	**0.90**
			2. *Zingiber officinale*		
6. Inflammation	anti-inflammatory	2	1. *Curcuma longa*	1.0	**0.78**
	follicular pharyngitis	8	1. *Globba winitii*	0.9	
			2. *Zingiber purpureum*		
7. Injuries	Wound	10	1. *Curcuma longa*	0.9	**0.90**
			2. *Curcuma rubescens*		
8. Mental Disorder	Neurotrophic	4	3. *Boesenbergia rotunda*	1.0	**1.00**
9. Muscular-Skeletal System Disorder	Muscular pain	46	1. *Alpinia malaccensis*	0.8	**0.80**
			2. *Curcuma zanthorrhiza*		
			3. *Curcuma longa*		
			4. *Etlingera linguiformis*		
			5. *Hedychium coccineum*		
			6. *Zingiber chantaranothaii*		
			7. *Zingiber purpureum*		
			8. *Zingiber ottensii*		
			9. *Alpinia galanga*		
			10. *Alpinia nigra*		
			11. *Kaempferia galanga*		
			12. *Zingiber officinale*		

10. Non-vertebrate poison	Insect bites	16	1. *Curcuma zanthorrhiza* 2. *Curcuma longa* L.	0.9	**0.86**
	Vermifuge	6	1. *Alpinia galanga* 2. *Alpinia nigra*	0.8	
11. Nutritional Disorder	Tonic	22	1. *Kaempferia parviflora* 2. *Kaempferia roscoeana*	1.0	**1.00**
12. Pregnancy/Birth/Puerperium Disorder	Galactic	4	1. *Zingiber officinale*	1.0	**0.93**
	post obstetric	54	1. *Curcuma zanthorrhiza* 2. *Etlingera linguiformis* 3. *Zingiber purpureum* 4. *Zingiber ottensii* Valeton	0.9	
13. Respiratory System Disorder	Antitussive	22	1. *Alpinia malaccensis* 2. *Alpinia roxburghii* 3. *Curcuma longa* 4. *Zingiber officinale*	0.9	**0.90**
14. Skin/Subcutaneous Cellular Tissue Disorder	Burns	4	1. *Kaempferia galanga*	1.0	**0.84**
	Intumesce	2	1. *Curcuma angustifolia*	1.0	
	Itchy	26	1. *Curcuma angustifolia* 2. *Curcuma longa* 3. *Hedychium fravescens* 4. *Hedychium coronarium* 5. *Hedychium coccineum*	0.8	

The native Zingiberaceae species were important traditional medicinal plants for the ethnic groups in northern Thailand. They were used for treating basic ailments, especially the symptoms of digestive system disorders. Therefore, out of 26 species used as medicine, 14 (54%) were used to treat digestive system disorders. Among these, some species were well-known for their usage as digestive problem treatments as they were reported for this use in other countries. For example, *Alpinia galanga* (Fathir et al. 2021; Kasarkar and Kulkarni 2016), *A. nigra* (Tushar et al. 2010), *Boesenbergia rotunda* (Fathir et al. 2021), *Curcuma longa* (Fathir et al. 2021; Kasarkar and Kulkarni 2016), *Zingiber officinale* (Fathir et al. 2021), *Z. purpureum* (Tushar et al. 2010), *Z. zerumbet* (Ghasemzadeh et al. 2016; Kasarkar and Kulkarni 2016). The carminative in the digestive system disorder had the highest use reports from these ethnic groups. This was supported by the property of volatile oils in the Zingiberaceae, helping to relieve gas in the alimentary tract (Fitria et al. 2019; Information 2016; Li et al. 2013).

The post obstetric in pregnancy/birth/puerperium disorder also had high use reports; only four local Zingiberaceae species were mentioned, including *C. zanthorrhiza*, *E. linguiformis*, *Z. purpureum*, and *Z. ottensii*. Among these species, *Z. purpureum* is the most common; this plant is widely used as postpartum medicine in Thailand. For the northern part, it was used by many ethnic groups to treat postpartum nervous, e.g., H'tin (Pongamornkul et al. 2017), Karen (Pongamornkul et al. 2017), Lawa (Songsangchun 2015), and Shan (Pongamornkul et al. 2017). However, although using these plants to treat the postpartum disorder is common among ethnic people in Thailand, it was rarely found in other countries (Fitria et al. 2019; Fathir et al. 2021).

Zingiberaceae species were used differently by different ethnic groups in northern Thailand, especially used as medicines, in terms of species and the way of uses. The usage of some species like *C. amada* and *Globba winitii* were reported only by Shan people, while *C. rubrobracteata* and *Z. tenuiscapus* were used only by Lawa and Skaw people, respectively. Common species like *Alpinia galanga* were used differently by ethnic groups. Shan people used this species to treat dizziness and vermifuge, but the Lisu people used it to treat muscular pain. Furthermore, the Lahu people used this species to treat food poisoning. Only *Z. purpureum* was used widely and similarly by all ethnic groups, especially for post-obstetrics. This species was especially important for folk midwives.

Local Zingiberaceae rhizomes were usually used for spices and traditional medicine because this part contained many essential oils and showed signs of multiple activities (Li et al. 2013; Ghasemzadeh at. al. 2016). At the same time, soft parts of local Zingiberaceae species, like flowers and pseudostems, were usually used for food, especially as vegetables. Analysis of the nutritional composition and phytochemical properties of the edible flowers from selected Zingiberaceae found in Thailand proved they were rich sources of potentially important nutrients (Rachkeeree et al. 2018). Unlike medicinal uses, traditional uses of Zingiberaceae species for vegetables were common for all ethnic groups. In addition, the young inflorescence and leaves of local Zingiberaceae species were important seasonal vegetables.

One of the key characteristics of the ginger species is the production of a unique scent. This feature could help the local people to recognize and identify the ginger species. This could facilitate the villagers, even the less experienced people, to remember these usable species. That could be one of the reasons why ginger species are frequently cited as one of the most important families in ethnobotanical studies.

Zingiberaceae is one of the largest families in Thailand, with more than 300 species. The previous comprehensive pharmacological review of the ginger family in Thailand has recorded 76 ginger species that were previously recorded in ethnobotanical studies in Thailand (Phumthum and Balslev 2020). In this study, 26 ginger species were

recorded for their ethnopharmacological properties. Among these, 12 species were first recorded. These species include *Alpinia nigra, Boesenbergia kingii, Curcuma angustifolia, C. rubescens, Etlingera linguiformis, Globba winitii, Hedychium coronarium, H. fravescens, Kaempferia roscoeana, Wurfbainia schmidtii, Zingiber chantaranothaii*, and *Z. tenuiscapus*. The high proportion (46%) of these first-time recorded species implied that more effort is needed to compile the traditional knowledge, especially in a large family like Zingiberaceae. Although the ginger family is easy to recognize, it is difficult to identify at the species level, especially the wild species. Many different species which were encountered during the fieldwork were considered the same species by the informants. Moreover, most ginger species flower during the rainy season, which is the most difficult time for fieldwork. Therefore, plants must be cultivated and wait for their flower for correct identification. Time is needed for this stage since some species require 2-3 years to flower in the nursery.

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REFERENCES

Al-Robai SA, Ahmed AAE, Mohamed HA, Ahmed AA, Zabin SA, Alghamdi AAA. 2022. Qualitative and quantitative ethnobotanical survey in Al Baha Province, Southwestern Saudi Arabia. Diversity 14 (10): 867. DOI: 10.3390/d14100867.

Chaachouay N, Benkhnigue O, Fadli M, El Ibaoui H, Zidane L. 2019. Ethnobotanical and ethnopharmacological studies of medicinal and aromatic plants used in the treatment of metabolic diseases in the Moroccan Rif. Heliyon 5 (10): e02191. DOI: 10.1016/j.heliyon.2019.e02191.

Cook FEM. 1995. Economic Botany Data Collection Standard. Whitstable Litho, Kent, Great Britain.

Fathir A, Haical M, Wahyudi D. 2021. Ethnobotanical study of medicinal plants used for maintaining stamina in Madura ethnic, East Java, Indonesia. Biodiversitas 22 (1): 386-392. DOI: 10.13057/biodiv/d220147.

Fitria R, Seno DSH, Priosoeryanto BP, Hartanti, Nurcholis W. 2019. Volatile compound profiles and cytotoxicity in essential oils from rhizome of *Curcuma aeruginosa* and *Curcuma zanthorrhiza*. Biodiversitas 20 (10): 2943-2948. DOI: 10.13057/biodiv/d201024.

Friedman J, Yaniv Z, Dafni A, Palewitch D. 1986. A preliminary classification of the healing potential of medicinal plants, based on a rational analysis of an ethnopharmacological field survey among Bedouins in the Negev Desert, Israel. J Ethnopharmacol 16: 275-287. DOI: 10.1016/0378-8741(86)90094-2.

Ghasemzadeh A, Jaafar HZE, Ashkani S, Rahmat A, Juraimi AS, Puteh A, Mohamed MTM. 2016. Variation in secondary metabolite production as well as antioxidant and antibacterial activities of *Zingiber zerumbet* (L.) at different stages of growth. BMC Complement Altern Med 16: 104. DOI: 10.1186/s12906-016-1072-6.

Gruca M, Cámara-Leret R, Macía MJ, Balslev H. 2014. New categories for traditional medicine in the Economic Botany Data Collection Standard. J Ethnopharmacol 155: 1388-1392. DOI: 10.1016/j.jep.2014.06.047.

Heinrich M, Ankli A, Frei B, Weimann C, Sticher O. 1998. Medicinal plants in Mexico: Healers' consensus and cultural importance. Soc Sci Med 47 (11): 1859-1871. DOI: 10.1016/s0277-9536(98)00181-6.

Information ND. 2016. National list of major drugs and empirical evidence. Main Report. http://ndi.fda.moph.go.th.

Junsongduang A, Balslev H, Inta A, Jampeetong A, Wangpakapattanawong P. 2014. Karen and Lawa medicinal plant use: uniformity or ethnic divergence? J Ethnopharmacol 151: 517-527. DOI: 10.1016/j.jep.2013.11.009.

Kasarkar AR, Kulkarni DK. 2016. Traditional knowledge of medicines belonging to family Zingiberaceae from South Western Maharashtra, India. Intl J Bot Stud 1 (4): 20-23.

Khamtang L, Saensouk S, Saensouk P, Thanonkeo S. 2014. Species diversity utilization of Zingiberaceae in Phu Laenkha National Park, Chaiyaphum province. KKU Res J 19: 794-803.

Khiankhan N. 2017. Diversity and Utilization of Zingiberaceae at Banthad Range, Peninsular Thailand. [M.TM. Dissertation]. Prince of Songkla University. [Thai]

Kufer J, Förther H, Pöll E, Heinrich M. 2005. Historical and modern medicinal plant uses - the example of the Ch'orti' Maya and Ladinos in Eastern Guatemala. J Pharm Pharmacol 57 (9): 1127-1152. DOI: 10.1211/jpp.57.9.0008.

Larsen K, Larsen SS. 2006. Gingers of Thailand. Queen Sirikit Botanic Garden, The Botanic Garden Organization, Chiang Mai, Thailand.

Leonti M. 2022. The relevance of quantitative ethnobotanical indices for ethnopharmacology and ethnobotany. J Ethnopharmacol 288: 115008. DOI: 10.1016/j.jep.2022.115008.

Li Y-H, Chen F, Wang J-F, Wang Y, Zhang J-Q, Guo T. 2013. Analysis of nine compounds from *Alpinia oxyphylla* fruit at different harvest time using UFLC-MS/MS and an extraction method optimized by orthogonal design. Chem Cent J 7: 134. DOI: 10.1186/1752-153X-7-134.

Nontasit N, Kanlayanapaphon C, Mekanawakul M, Nualmangsar O. 2015. Taxonomic studies and traditional uses of Zingiberaceae in Khao Luang National Park, Nakhon Sri Thammarat province, Thailand. Walailak J Sci Technol 12: 643-658. DOI: 10.14456/WJST.2015.64.

Numpulsuksant W, Saensouk S, Saensouk P. 2021. Diversity and ethnobotanical study of medicinal plants in Ban Hua Kua, Kae Dam District, Thailand. Biodiversitas 22 (10): 4349-4357. DOI: 10.13057/biodiv/d221027.

Panyadee P, Wangpakapattanawong P, Inta A, Balslev H. 2023. Very high food plant diversity among ethnic groups in Northern Thailand. Diversity 15 (1): 120. DOI: 10.3390/d15010120.

Phumthum M, Balslev H. 2020. Using ICPC-2 Standard to identify Thai Zingiberaceae of pharmacological interest. Plants 9 (7): 906. DOI: 10.3390/plants9070906.

Phumthum M, Srithi K, Inta A, Junsongduang A, Tangjitman K, Pongamornkul W, Trisonthi C, Balslev H. 2018. Ethnomedicinal plant diversity in Thailand. J. Ethnopharmacol 214: 90-98. DOI: 10.1016/j.jep.2017.12.003.

Pongamornkul W, Trisonthi C, Trisonthi P, Inta A. 2017. Northern Thailand Ethnobotanical Index. Queen Sirikit Botanic Garden, The Botanic Garden Organization, Chiang Mai. Thailand. [Thai]

Rachkeeree A, Kantadoung K, Suksathan R, Puangpradab R, Page PA, Sommano SR. 2018. Nutritional compositions and phytochemical properties of the edible flowers from selected Zingiberaceae found in Thailand. Front Nutr 5: 1-10. DOI: 10.3389/fnut.2018.00003.

Ragsasilpt A, Saensouk P, Saensouk S. 2022. Ginger family from Bueng Kan Province, Thailand: Diversity, conservation status, and traditional uses. Biodiversitas 23 (5): 2739-2752. DOI: 10.13057/biodiv/d230556.

Saensouk P, Saensouk S. 2021. Diversity, traditional uses and conservation status of Zingiberaceae in Udorn Thani Province, Thailand. Biodiversitas 22 (8): 3083-3097. DOI: 10.13057/biodiv/d220801.

Saensouk S, Saensouk P, Pasorn P, Chantaranothai P. 2016. Diversity and uses of Zingiberaceae in Nam Nao National Park, Chaiyaphum and Phetchabun provinces, Thailand, with a new record for Thailand. Agric Nat Resour 50: 445-453. DOI: 10.1016/j.anres.2016.08.002.

Saensouk S, Saensouk P. 2018. Diversity and traditional uses of Zingiberaceae. Res Knowl 4: 47-55.

Songsangchun A. 2015. Plants Usages of Khon Muang and Lawa in Phu Fah Subdistrict, Bo Klua District, Nan Province, Thailand. [M.S. Dissertation]. Chiang Mai University. [Thai]

Tangjitman K, Wongsawad C, Kamwong K, Sukkho T, Trisonthi C. 2015. Ethnomedicinal plants used for digestive system disorders by the Karen of northern Thailand. J Ethnobiol Ethnomed 11: 1-13. DOI: 10.1186/s13002-015-0011-9.

Tushar BS, Sarma GC, Rangan L. 2010. Ethnomedical uses of Zingiberaceous plants of Northeast India. J Ethnopharmacol 132 (1): 286-296. DOI: 10.1016/j.jep.2010.08.032.