

The Secret of Health in the Daily Cuisine: the Typical Health Vegetables in the Local Markets in Central Myanmar

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Abstract

Background

Central Myanmar locate in the Indo-Burma Biodiversity hotspot, and Barma people is the main ethnic group which had settled there over thousands years ago. Nevertheless, as the major Myanmar ethnic group, Bamar people were ignored in Ethnobotanical studies. Market surveys are considered a good strategy for the preliminary screening of potential Ethnopharmacological plant resources. In the present study, we focused on the local health knowledge of vegetables of Bamar people in local markets.

Material and methods:

In the present study, we surveyed the local markets, then recorded, collected, identified and catalogued the typical vegetables, and document the knowledge of health benefits of the collected vegetables, then analyze the information of vegetables and local knowledge. The observation and interviews were used in field study, and the Ethnobotanical Indexes were used to analyze the local knowledge. We compare the local knowledge we collected with traditional medicine literatures.

Results

10 Markets and fairs were selected in Mandalay Region, Magway Region, Yangon Region and Nay Pyi Taw Union Territory, and in a total of 277 vegetable stalls or shops were visited. 132 plant taxa were collected and identified. Many of the healthy vegetables were cited as functional food had health benefit by the informants (106 taxa, 80.3%) while others were just regarded as "good for health" (26 taxa, 19.7%). Over half of the taxa were recorded as traditional medicinal plants with health functions in previous studies. The main health function of the vegetables was treating digestion problems.

Conclusion

The diversity and use of the health vegetables in central Myanmar were very rich. Some previous Phytochemical and Pharmacological studies on these plants showed that their extracts had effective activities or compounds related to health functions. It should be noted the food safety of the vegetables in future researches.

Yu Zhang and Jian-Wen Li contribute equally to the article.

1 Background

Local knowledge of health is great treasure for resource development and drug discovery in Pharmacology. Health food especially health vegetables are important resources for local people to maintain health [1], especially in Asian countries such as China, India, Thailand and Japan. For example, for the popularity of traditional health preserve principle, the dietetic Chinese herbs were used widely in Chinese daily cuisine [2]. In India, people used Medicinal flavor plants such as turmeric and cumin in cooking to treat digestion problems [3]. In the native people's home gardens in North Thailand, mango, jackfruit and lemon grass were very common, for cooking Traditional functional food [4]. The health benefits of Japanese fermented soy "natto" had been verified by some scientific researches such as Nagata et al (2016) [5] and Fujita et al (2012) [6]. Local people had abundant knowledge of the collection, preparation, cooking, cultivation, edible safety, health function and resource management of the vegetables [7]. According to our previous researches, there were abundant functional compounds in health vegetables [8]. Besides, health vegetables were important sources of micro-minerals and vitamins [9] [10]. Therefore, these vegetables had enormous potential for health related researches and industries such as drug discover, food nutritional engineering and pharmaceutical industry. Finding inspiration from the local health knowledge in daily cuisine became a focus in Ethnopharmacology and Ethnobotany. However, most of the local knowledge just was known by native people or transmitted in small and limited areas. That means these knowledge would be very easy to disappear with time [7]. Moreover, the global change and biodiversity loss would promote the disappearing of and local knowledge [11]. Hence, it was very necessary to collect, document, analyze and explain scientifically the local knowledge of health vegetables. There were many researches about local health food had been published in the mainstream journals of Ethnobiology, Ethnopharmacology and Alternative Medicine such as Journal of Ethnobiology and Ethnomedicine, Journal of Ethnopharmacology, Economic Botany, etc. Nevertheless, for some less developed countries or remote poor regions, there were still few related researches.

Myanmar, lies between China and India, is well known for its rich biodiversity and culture diversity. As one of the key regions designated as global hotspots for biodiversity protection, Myanmar had an abundance of plant resources [12]. The U.S. National Herbarium, the Forest Department of Myanmar and the University of Yangon had provided a Myanmar plant checklist contained over 3000 species [13], KM Lwin & MKT Lwin catalogue a list of medicinal plants in Myanmar including 1500 species [14], and Defilippis et al [15] had reviewed the main information of the 472 Myanmar Medicinal plant species recently. In Myanmar, since thousands of years before, Buddhism had impacted almost every aspect of Myanmar including medicine. Vinaya, which was one of the Tripitaka of Buddhism about the regulation of life, became the basis of Myanmar Traditional medicine. In Buddhism Vinaya practices, a qualified Buddhist should follow strict diet rules to keep health of both body and spirit. Because the unhealthy dietary habits and bad foods would cause serious digestion problems which would be detrimental to the Buddhist practice [3]. Therefore, beside medicine, Myanmar people also used food to keep health and treat ailments by following Vinaya in traditional lifestyle, as the well-known Myanmar proverb went that "medicine was food, food was medicine". However, there were still few researches in international journals and books. The only several related researches published in English showed rich local medicinal knowledge of the ethnic minority communities in Chin State [16], Shan State [17], Kachin State [18] and Mon State [19]. Nevertheless, as the major Myanmar ethnic group, Bamar people seemed be ignore in Ethnobotanical studies.

Market surveys were considered as a good strategy for the preliminary screening of potential Ethnopharmacological plant resources [7]. According to the related previous researches, markets were important to glimpse the diversity and trade structure of the medicinal flora of a country or region [20–23]. Markets also reflected the public health and epidemic diseases of local communities [24]. Participating in markets was an important way for people to exchange goods, information and knowledge. As “showing stages” of local knowledge, local markets had been focused on by many researchers [25]. Local food markets were systems for food material and information exchange, which delivered health, economic, environmental and social benefits to the local communities [26]. In general, vegetables should be kept fresh before sale, so most of the vegetables in food market were from local place. Therefore, local food markets were ideal places to research the diversity and use knowledge of local vegetables [27–30].

With the funding of National Science Foundation of China and Southeast Asia Biodiversity Research Institute, Chinese Academy of Sciences (SEABRI-CAS) and the supports of Myanmar Forest Research Institute (FRI), we designed and carried the present study^{**}. In our preliminary investigation, we found that there was great diversity of vegetables in the local food markets of Myanmar [8].

It raised questions below to us: 1) how many species of local typical vegetables were sold in these markets? 2) How many species of them were regarded as health vegetables by local people? 3) Which species were also recorded as medicinal plants in available Traditional Myanmar Medicine literatures and books, and whether the local health knowledge of plants was similar with the records in the Traditional Myanmar Medicine literatures and books or not?

Due to this, in this paper, our main work would include: 1) surveying the local markets, then recording, collecting, identifying and cataloguing the typical vegetables, 2) interviewing local people and documenting the knowledge of health benefits of the collected vegetables, then analyzing the information of vegetables and local knowledge, 3) comparing the local knowledge we collected with traditional medicine literatures.

2 Material And Methods

2.1 Study area

Central Myanmar is well recognized by its history and ancient civilization. Central Myanmar was the birth and flourished place of Myanmar Culture, and almost all of the capitals of Myanmar historical dynasties located in Central Myanmar, such as Sri-ksetra, Hanthawaddy, Bagan, Bago, Taungoo, Inwa, Shwebo, Amarapura and Mandalay [31]. Most of the native residents of Central Myanmar were Bamar people, the main ethnic group of Myanmar who settled there over one thousand years ago. Most of the Bamar people were Theravada Buddhists, and the Buddhist belief deeply affects the lifestyles of Bamar people [31].

Generally, Central Myanmar was classified as tropical wet and dry climate zone. Due to the rain shadow of Arakan Mountain, a big part of Central Myanmar had a hot semi-arid climate. Nourished by the Ayeyarwady River, it is characterized by fertile soil, which made it the area most important agricultural district of Myanmar, especially for rice production [32].

2.2 Field survey and data collection

The survey was carried in 10 regular markets of Mandalay Region, Magway Region, Yangon Region and Nay Pyi Taw Union Territory (Fig. 1), representing the typical food markets of Central Myanmar. Because Mandalay is regarded as the center of Myanmar culture, half of these markets were in the Mandalay City. In total, 277 vegetable stalls or shops with random selection were investigated and plants species found in these stalls and shops were recorded. Vegetables that are not largely worldwide cultivated were of the major focus for our survey.

The frequency of occurrence of each vegetable were investigated and evaluated in the following methods. Firstly, we cruised the target market quickly and counted the number of shops or stalls with numeric counters, for the purpose of knowing the sizes and number of the shops or stalls to establish the number of randomly selected shops or stalls in each target market. Secondly, we used digital cameras to record the full image of vegetables soled at each randomly selected shop or stall. Finally, we recorded species found at each shop or stall by reviewing the photos. After that, the frequency of occurrence for each species was calculated. Meanwhile, the owners of these shops or stalls were set as the informants for participatory observation and semi-structured interviews. Data were organized in Excel sheet for further analysis. Voucher specimens of species were prepared and identified with the help of specialist at Kunming Institute of Botany, Chinese Academy of Sciences, China and at the Forest Research Institute, Myanmar.

Participatory observation and semi-structured interviews were conducted with informed consent to informants for gathering knowledge on the health benefits of vegetables. Methods of preparation, function and amount of usage for were recorded for species with health benefit. Habitat and source information of the vegetable were recorded. The interviews were carried out in Burmese and then translated into English with the facilitation of Myanmar collaborators from Forest Research Institute (FRI). The informants were mainly vegetable sellers in the markets.

2.3 Species identification

Voucher specimens were collected for most species (70%) and deposited at the Herbarium of Myanmar Forest Research Institute (RAF) and Herbarium of Kunming Institute of Botany (KUN) (Appendix A), except for those common vegetables such as cabbage, tomato and eggplant. The identification was based on “A Checklist of the Trees, Shrubs, Herbs, and Climbers of Myanmar” [13] and the flora of surrounding area such as Flora of China [33] and Flora of Yunnan [34]. The scientific names were finally checked using service provided by The Plant List [35].

2.4 Categorizing functions and conservation status of the vegetables with health benefits

In traditional and local (folk) medicinal systems, the descriptions of ailments and diseases were usually diverse, which may cause difficulties in analysis. Thus, it was necessary to normalize the information with common standards before analysis. In the present study, all of the ailments were categorized with

the classification of the patient's reason for encounter (CPRE)" from WHO. (<http://www.who.int/classifications/icd/adaptations/icpc2/en/>). The Species conservation status was checked with the IUCN Red List version 2019-2 [36].

2.5 Quantitative ethnobotany analysis

The use reports were prepared following Tardío and Pardo-de-Santayana (2008) [37], which were further used for calculating quantitative ethnobotany indices including frequency of citation (FC), relative frequency of citation (RFC) and use value (UV).

Frequency of citation (FC) was calculated as the sum of informants that cite a use for a particular species. Relative frequency of citation (RFC) was used to show the importance of each species in the study area [41]. The values of RFC were calculated according to the formula:

$$RFC = \frac{FC_s}{N}$$

Where FC_s was the Frequency of Citation and N was the total number of informants in the survey. A high RFC value for a species indicates that the species was used both frequently and by a high proportion of informants in the study area.

Use value (UV) was used to measure the relative importance of species used locally [38]. The values of UV were calculated according to the formula:

$$UV = \frac{\sum U_i}{n}$$

Where U_i was the number of use reports cited by each informant for a given species and n refers to the total number of informants. A high value of UV indicates that a species is important and used frequently in the study area.

2.6 Bibliographies Comparison

The information of health benefits were compared with available literatures of Traditional Myanmar Medicine (TMM) and modern Phytochemical and Pharmacological researches. The references of Traditional Myanmar Medicine were from the authoritative publications and researches on TMM, including Defilippis and Krupnick (2018) [15], Kyaw Soe & Tin Myo Ngwe (2014) [39] and Ministry of Health Department of Traditional Medicine of Myanmar (2000) [40].

3 Results

3.1 Diversity, life form, part of use and usage of recorded vegetable species

In total, 132 plant taxa were documented, collected and identified to species level and two to genera level, which were belonged to 47 botanical families and 116 different genera (Appendix A). The most commonly found family was Fabaceae (17 species), followed by Cucurbitaceae (10 species). At genus level, most genera (105) contained one species while only 10 genera contained more than two species. Genera with most numbers of species were *Allium* (four species) and *Citrus* (four species). More than half (75 taxa) of them were herbaceous plants, followed by trees (27 species), climbers (18 taxa) and shrubs (12 taxa) (Fig. 2 - 1).

The plant part used were fruits (42 taxa), leaves (25 taxa), aerial stems (30 taxa), flowers (16 taxa), whole aerial parts (28 taxa) and underground parts (Totally 17 taxa) including rhizomes, tuber roots, tuber stems, bulbs and corms (Fig. <link rid="fig2">2</link>-2). The recorded vegetables were prepared and used as salads (100 taxa), curries (14 taxa), soups (82 taxa), fried dishes (2 taxa), and flavors (26 taxa) (Fig. 2-3).

3.2 The most popular vegetables

In total 2,361 use-reports (UR) were obtained from 277 informants. Twenty-five taxa had more than 100 use-reports while nine had just one use-report. Ranks top five species with high UR and UV values Mango (*Mangifera indica*, UR = 504, UV = 1.819), chili (*Capsicum annum*, UR = 455, UV = 1.643), okra (*Abelmoschus esculentus*, UR = 380, UV = 1.372), water spinach (*Ipomoea aquatic*, FC = 310, UV = 1.119) and cucumber (*Cucumis sativus*, UR = 273, UV = 0.986). The result of the RFC was slightly different from FC and UV. Chili, eggplant (*Solanum melongena*) and *Brassica rapa* (RFC = 0.329) had the highest values of RFC, followed by tea leaf (*Camellia sinensis* var. *assamica*, RFC = 0.271), water spinach (RFC = 0.227) and okra (RFC = 0.209).

3.3 The wild vegetables

Twenty eight species were not cultivated but collected from wild environment (Table 1). Amongst which *Dregea volubilis* (UR = 230) was the most frequently seen species in the markets and followed by *Centella asiatica* (UR = 105). These species were also recorded as medicinal plants in the in authoritative on Traditional Myanmar Medicine [15, 39-40].

Table 1
the vegetables collected from wild place

Science Name	vernacular Name	Family	Use Part	Life form	Habitat	Distribution in Myanmar 1	Preparation as vegetable	Local Medicinal Use
<i>Asystasia gangetica</i> (L.) T.Anders.	အိတ်အိတ်	Acanthaceae	tender leaf	herb	Tropical dry forest	Mandalay	Blanch the tender leaves into boiling water, then make salads	treating traumatic injury
<i>Bauhinia acuminata</i> L.	ပုလဲ	Fabaceae	tender leaf	shrub	Forests in tropical or subtropical region	distributing wildly in most parts of Myanmar	Making salads	treating dyspepsia and constipation
<i>Bombax ceiba</i> L.	ပုလဲ	Malvaceae	Flower	tree	Tropical dry forest	distributing wildly in most parts of Myanmar	Blanch the flowers into boiling water, then make salads or enjoy directly with Myanmar style dipping sources. Besides, flowers are usually sun dried for keeping.	treating diarrhea
<i>Centella asiatica</i> (L.) Urb.	အိတ်အိတ်	Apiaceae	whole plant	herb	wet land	whole Myanmar	make salads and soups directly	treating insomnia and forgetfulness
<i>Cheilocostus speciosus</i> (J.Koenig) C.D.Specht	အိတ်အိတ်	Zingiberaceae	stem	herb	Distribute widely in tropical and subtropical region	whole Myanmar	Blanch the flesh rhizomes into boiling water, then make salads	treating digestion problems
<i>Chenopodium album</i> L.	အိတ်အိတ်	Amaranthaceae	tender leaf	herb	distribute widely in various habitats	whole Myanmar	make salads and soups directly	treating constipation
<i>Curcuma aromatica</i> Salisb.	အိတ်အိတ်	Zingiberaceae	rhizome; flower	herb	Distribute widely in tropical and subtropical region	whole Myanmar	rhizomes are used as spice. Flowers are used to make salads.	treating digestion problems
<i>Cynodon dactylon</i> (L.) Pers.		Poaceae	whole plant	herb	distribute widely in various habitats	whole Myanmar	Whole plants are mashed to make salad	using as diuretic and heat-clearing
<i>Dregea volubilis</i> (L.f.) Benth. ex Hook.f.	အိတ်အိတ်	Apocynaceae	flower; tender shoot and leaf	climber	Forests in tropical or subtropical region	whole Myanmar	Blanch the fresh flowers, tender shoots and leaves into boiling water, then make salads	using as heat-clearing drug
<i>Eclipta prostrata</i> (L.) L.	အိတ်အိတ်	Asteraceae	tender shoot	herb	wet land	Mandalay, Nay Pyi Taw, Sagaing, Taunggyi	Blanch the tender shoots into boiling water, then make salads	Treating blood diseases, liver diseases and hyperlipidemia.

Science Name	vernacular Name	Family	Use Part	Life form	Habitat	Distribution in Myanmar ¹	Preparation as vegetable	Local Medicinal Use
<i>Elaeagnus conferta</i> Roxb.	ပဲခူးပင်	Elaeagnaceae	fruit	shrub	wet land	Shan	the fruits are used as sour flavor in salads and soups	Treating diarrhea, dysentery, coughing and wheezing
<i>Enydra fluctuans</i> DC.	ပဲခူးပင်	Asteraceae	tender shoot	herb	wet land	Widely distribute in Myanmar	Blanch the tender shoots into boiling water, then make salads	reduce blood press
<i>Houttuynia cordata</i> Thunb.		Saururaceae	rhizome; tender shoot	herb	wet land	whole Myanmar	make salads	diuretic and anti-inflammatory
<i>Hydrocotyle verticillata</i> Thunb.	ပဲခူးပင်	Araliaceae	whole plant	herb	wet land	Mandalay	make salads and soups directly	Treating acute hepatitis
<i>Lasia spinosa</i> (L.) Thwaites	ပဲခူးပင်	Arecaceae	tender leaf	herb	wet land	Mandalay Region, Yangon Region	make salads and soups directly	using as aperient
<i>Ludwigia adscendens</i> (L.) H.Hara	ပဲခူးပင်	Onagraceae	tender shoot	herb	wet land	Kachin State, Sagaing Region, Shan State and Chin State	Blanch the tender shoots into boiling water, then make salads	Treating diarrhea
<i>Markhamia stipulata</i> (Wall.) Seem.	ပဲခူးပင်	Bignoniaceae	flower	tree	Tropical dry forest	distributing wildly in most parts of Myanmar	Collect the flowers, then remove all the parts except the corollas, then blanch the corollas in boiling water, then use the corollas to make salads.	anti-cancer
<i>Neptunia plena</i> (L.) Benth.	ပဲခူးပင်	Fabaceae	whole plant	herb	wet land	Chin state, Shan state, Kachin State and Mandalay Region	make salads and soups directly	Clearing intestines and treating diarrhea.
<i>Oenanthe javanica</i> (Blume) DC.	ပဲခူးပင်	Apiaceae	whole plant	herb	wet land	Kachin, Sagaing	make salads and soups directly.	treating cold and flu
<i>Ottelia cordata</i> (Wall.) Dandy	ပဲခူးပင်	Hydrocharitaceae	flower	herb	wet land	Mandalay, Taunggyi, Nyaung Shwe, Kalaw	make salads and soups	treating tinea pedis
<i>Oxystelma esculentum</i> (Linn. f.) F. A. Schult.		Apocynaceae	tender shoot	climber	Tropical dry forest	ayeyarwady, Bago, Magway, Mandalay	make soups	anti-cancer
<i>Phyllanthus emblica</i> L.	ပဲခူးပင်	Phyllanthaceae	fruit	shrub	Tropical dry forest	Mandalay, Taunggyi	the fruits are used as sour flavor in salads and soups	treating aging and insomnia. The fruits are used as "amalaka", one of the "Triphalla" in ayurvedic medicine.

Science Name	vernacular Name	Family	Use Part	Life form	Habitat	Distribution in Myanmar ¹	Preparation as vegetable	Local Medicinal Use
<i>Polygonum viscosum</i> Buch.-Ham. ex D. Don		Polygonaceae	Whole plants	herb	wet land	whole Myanmar	the whole plants are used as flavor in cooking	Treating digestion problems and anti-bacterial
<i>Portulaca oleracea</i> L.	ပုစိန်ပုစိန်	Portulacaceae	whole plant	herb	distribute widely in various habitats	whole Myanmar	make salads and soups	anti-diabetis
<i>Solanum torvum</i> Sw.	ပုစိန်ပုစိန်	Solanaceae	fruit	shrub	distribute widely in various habitats	whole Myanmar	make salads	Treating colds, coughs and urinary system diseases.
<i>Sonchus oleraceus</i> (L.) L.		Asteraceae	whole plant	herb	distribute widely in various habitats	Kachin, Sagaing, Mandalay	make salads and soups directly	using as heat-clearing drug
<i>Terminthia paniculata</i> (Wallich ex G.Don) C.Y.Wu & T.L.Ming	ပုစိန်ပုစိန်	Anacardiaceae	fruit	shrub	Tropical dry forest	Mandalay, Shan, Sagaing,	the fruits are used as sour flavor in salads and soups	Treating dysentery and gout arthritis.
<i>Ziziphus jujuba</i> Mill.	ပုစိန်	Rhamnaceae	fruit	shrub	Tropical dry forest	Mandalay, Sagaing, Magwe	make salads and soups	Treating cardiovascular disease, constipation and arteriosclerosis.

1: the information was from Kress et al (2003)[13]

3.4 Health functions and medicinal uses

Many of the vegetables were cited as functional food with health benefit by the informants (106 taxa, 80.3%) while others were just regarded as “good for health” (26 taxa, 19.7%). The traditional knowledge on treatment of ailments was enlisted in Appendix B. Dyspepsia/indigestion (33 taxa), vitamin/nutritional deficiency (18 taxa), diarrhea (15 taxa) and weakness/tiredness general (8 taxa) were the major treatments or functions of the vegetables cited (Fig. 3).

Notes of Fig. 3: A: General and Unspecified, B: Blood, blood forming organs and immune mechanism, D: Digestive, F: Eye, H: Ear, K: Cardiovascular, L: Musculoskeletal, N: Neurological, P: Psychological, R: Respiratory, S: Skin, T: Endocrine/metabolic and nutritional, U: Urological, W: Pregnancy/child bearing, family planning

Sixty-four species were recorded as traditional Myanmar medicinal plants in authoritative on TMM, containing [15], [39] and [40]. In these publications and researches, respectively, 57 species were recorded in [15], 21 in [40], and 15 in [39] (Appendix B). Comparing the local health knowledge recorded in the present study and the records of these previous authoritative publications and researches, the local health knowledge of 35 species were similar with the records in [15], 17 in [40], and five in [39] (Fig. 4).

4. Discussion

4.1 Rich diversity of vegetable resources

We found a rich diversity of vegetable resources covering a broad range of genera and families from the markets of central Myanmar. The most frequently cited vegetables were commonly appeared elsewhere in the region, and been noted as “staple goods”, which reflects the fact that large scale cultivated vegetables comprises the major source of vegetables for the urban population of central Myanmar. However, still, twenty-eight species were of the vegetables we recorded were collected from wild places.

Among the taxa recorded, 57 species were also noted as medicinal plants by Defilipps and Krupnick [15], in which 35 species had similar function with the result of our study. Likewise, 22 species and 15 species were found in common with the Herbal book edited by Ministry of Health Department of Traditional Medicine of Myanmar in 2000 [40] and with the results of Kyaw Soe and Tin Myo Ngwe in 2014 [39], respectively.

Comparing with previous studies in the regions (Indo-China Biodiversity hotspot region), central Myanmar was relatively high in terms of wild plant diversity used as vegetables. For example, in Yunnan Province of China, 68 species of wild plants were used as health vegetables by native people of Wa, Blang, Lahu and Dai Ethnic Nationalities [41]. In Chiang Mai Province of Thailand, 94 woody plants such as mango and fig species were cultivated for vegetables, fruits and other uses in home gardens [42]. In Koch Bihar District of West Bengal of India, 125 species were recorded as edible plants [43].

Twenty-six taxa were assessed by The International Union for Conservation of Nature. Just only one species (*Kaempferia candida*) was designated as endangered species at the Vulnerable (VU) level, while others were not endangered. The only endangered species was just only noted two times (UR = 2) by

two isolated informants. The informants claimed that they cultivated the plant in their home gardens.

4.2 Important vegetables and their health function

From the results of quantitative analysis, some of the recorded plants were important for local people. These plants were used repeatedly in the local daily cuisines, some of them had health functions claimed by local people (Fig. 5).

Note 1: a vegetable stall. 2: typical vegetable salad mix dish of the local daily cuisines. 3: inflorescences of *Curcuma longa*. 4: Fermented tea leaf. 5: *Dregea volubilis*. 6: *Abelmoschus esculentus*. 7: *Psophocarpus tetragonolobus*. 8: *Capsicum annuum*. 9: Mango salad. 10: Fresh mango. 11: *Centella asiatica*

As indicated by the values of UV and RFC, mango (*Mangifera indica*) was the most cited vegetable in the present study. As a native species [44], *Mangifera indica* had been used by Myanmar people for a long time [45], and in multiple ways. There was a well-noted proverb saying "Mango was the best fruit and tea leaf was the best leaf" [46]. The mango leaves were used as medicine for treating diarrhea, and the young sour fruits are made into salad, while the matured sweet fruits are one of the most famous tropical fruits.

Fermented tea leaf (La-phet) was a unique vegetable to be found in Myanmar [46]. It was a typical traditional gradient in the daily serve to the tables. It was considered to be beneficial to digestion by local people. The main species of used was *Camellia sinensis* var. *assamica*, which was identical to that of Pu'er tea in Chinese Tea. According to the informants, the fermented sour tea leaf is beneficial to digestion.

Chili (*Capsicum annuum*) is an important gradient in Myanmar's cuisines as well as in its neighboring countries. The uses of *C. annuum* in South and Southeast Asia could be traced to 500 years ago when Portugal merchants introduced the species to India [47]. There were many cultivars sold in the markets, and the appearance and taste vary. Not only as a popular spice, *C. annuum* was a common medicinal plant in Traditional Myanmar Medicine [15]. It is used to treat cold diseases and digestion problems by local people.

Okra (*Abelmoschus esculentus*), originated from Africa and spread to almost all of the tropical and sub-tropical regions [48–49], is very common in Myanmar daily diet and used to treat diabetic patients. Water spinach (*Ipomoea aquatic*) is one of the most popular vegetable in Myanmar, and it is usually cooked with mushrooms, where water spinach was a powerful antidote activity to relieve the poison of mushrooms according to the informants.

Fabaceae was the most used family including 17 species by local people. They were mainly cultivated as the source of protein which mainly contained in the seeds. Apart from seeds, local people also collect tender leaves, shoots, flowers and flesh roots as vegetables. For example, the tender shoots, fruits and flesh roots of *Psophocarpus tetragonolobus* were collected as vegetables in different seasons by local people. In Traditional Myanmar Medicine, the tender fruits were used to treat diabetes, while the leaves were used to treat eye diseases and toothache. The previous research showed that the leaves of this species is rich in protein, and vitamin A and C [50].

Species from Zingiberaceae were also important component in the local cuisine. Eight Zingiberaceae species were recorded in the present study with *Curcuma longa* (UR = 80) as the mostly frequently occurred species. *C. longa* was also named as Turmeric in English which was one of the most famous medicinal plants produced in tropical area. It could be used to treat digestion problems, according to the informants. Curcumin was identified as the functional ingredient of the specie, which was a polyphenol that possesses diverse anti-inflammatory and anti-cancer properties following oral or topical administration [8].

All of the vegetables collected from wild were used both for food and traditional medicine [15, 39–40]. These species were common in the natural vegetation of central Myanmar. In Traditional Myanmar Medicine, *Dregea volubilis*, the most used wild species, was used to treat multiple diseases such as Indigestion, dyspepsia, dysentery, diarrhea and insomnia [50]. The functional compounds of the species were identified as a group of Dregeosides which had effective activities such as antibacterial, antioxidant and antidiabetic [51–53]. *Centella asiatica* could improve the symptoms of insomnia and forgetfulness, according to the informants. In Traditional Myanmar Medicine, *C. asiatica* was used to treat memory impairment, oliguria and eye diseases [50]. A modern study found that the extract of the species had effective anti-Alzheimer's disease activities [54].

Even the most worldwide common vegetables, such as *Solanum melongena* and *Brassica rapa*, which had the highest values of RFC in the present study, were used for health care in particular way by local people. The informants claimed that *S. melongena* was a good tonic to treat weakness, and *B. rapa* was used to treat cancer and skin infection (external use). The previous studies had showed that there were some functional compounds with effective activities to human health in these vegetables [55–57]. For example, Glucosinolates, a group of effective compounds found in *Brassica rapa*, had many potential functions such as anti-microbe, anti-cancer and anti-parasites [58]. Nevertheless, there were still no clinic evidence to proof the anti-cancer activities for human body of these compounds.

4.3 Issue of food safety

Food safety was always an important topic. In the present study, some species found in the market are known to be poisonous or carcinogenic. The informants were aware the risk of consuming these species and local knowledge were available on the preparation and treatment of the raw plant materials before consume. The preparation includes blanching in boiled water, stewing with long time, boiling with detoxification material and salting. Some previous studies in food chemistry showed that the preparation methods can help to reduce toxins to certain degree [56]. For example, the corms of *Colocasia esculenta* were rich in needle-like calcium oxalate crystals which had heavy irritation to the oral and respiratory mucosa, but boiling long time with high temperature could reduce the irritation. High temperature cooking could also degrade the nephrotoxic compounds in *Archidendron pauciflorum*. For *Azadirachta indica*, the tender shoots and leaves should be boiled with sour material such as tamarinds until the bitter taste become thin first, then make salads and soups, because the bitter compounds of the species were regarded as toxic substances [8]. Yet, risks was still persisting, better management approaches for regulating and monitoring these poisonous vegetables and public awareness and education were fundamentally needed.

5 Conclusion

The diversity and use of the health vegetables in central Myanmar were very rich. The most frequent species were *Capsicum annuum*, *Solanum melongena*, *Brassica rapa*, *Camellia sinensis* var. *assamica* and *Ipomoea aquatic*, while *Mangifera indica*, *Capsicum annuum*, *Abelmoschus esculentus*, *Ipomoea aquatic* and *Cucumis sativus* had the richest uses and knowledge. These frequently used species were also used in Traditional Myanmar medicine, according to the records in the traditional Myanmar herb books. Just only one species (*Kaempferia candida*) was designated as Vulnerable (VU) by IUCN but not used frequently. According to the previous studies of some of the important species on Pharmacology, the related activities may be anti-bacterial, anti-fungus, anti-virus, anti-inflammation and anti-oxidation. In the present study, some species were poisons, local people had knowledge to reduce toxins. However, from the perspective of public health, just depend on the local knowledge to treat the problem of the food safety of health vegetables was not enough. The health department of government should to make policies to manage the sale the poisonous plant materials and guide the citizens to treat them before eating. Future researches could pay more attention to the material foundation of the health functions of these plants and their potential in natural drug discovery.

Declarations

Ethics approval and consent to participate

The authors declare that they have no competing interests.

Consent for publication

The people interviewed were informed about the study's objectives and the eventual publication of the information gathered, and they were assured that the informants' identities would remain undisclosed.

Availability of data and materials

Please contact author for data requests.

Competing interests

The authors declare that they have no competing interests.

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Authors' contribution

YXF organized the study team, and provided the technical supports and guidance. ZY and LJW designed and executed the research plan. wrote the manuscript. MMS provided the technical guidance and Myanmar language translation service in field works. CWW provided the technical guidance in data analysis and English writing. TTS, AMM and PPH recorded and organized the data. LJW and ZY identified the specimen and checked the information. All authors took part in the field works. All authors were involved in the drafting and revising of the manuscript and approved the final revision.

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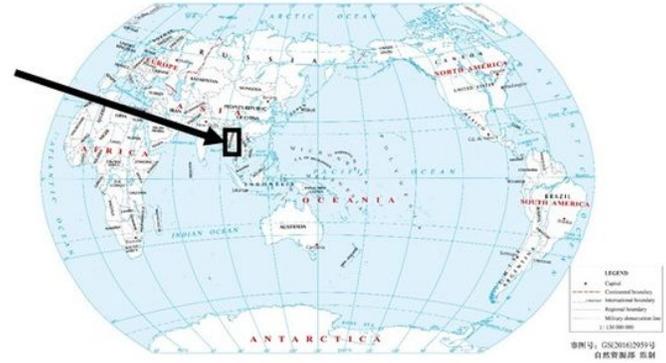
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Figures



Myanmar



▲ Study cities

Market	No. of visited stalls or shops	Altitude	Cities	Region
Zaycho	85	77m	Mandalay	Mandalay
35 street Market	18	81m	Mandalay	Mandalay
Nan Shay Market	19	80m	Mandalay	Mandalay
Sayar San Market	18	78m	Mandalay	Mandalay
Mingalar Market	29	85m	Mandalay	Mandalay
Thapyaygone Market	69	117m	Nay Pyi Taw	Nay Pyi Taw
Yezin Market	9	106m	Nay Pyi Taw	Nay Pyi Taw
Pantain street Market	8	34m	Pyay	Magway
Konzedan street Market	19	16m	Yangon	Yangon
Popa Mountain Market	3	641m	Popa	Mandalay

Figure 1

the study sites and markets

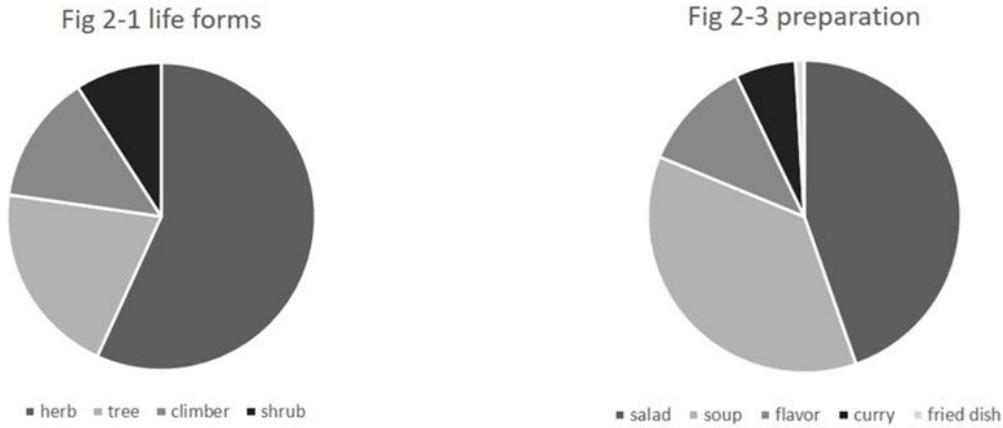


Fig2-2 use parts

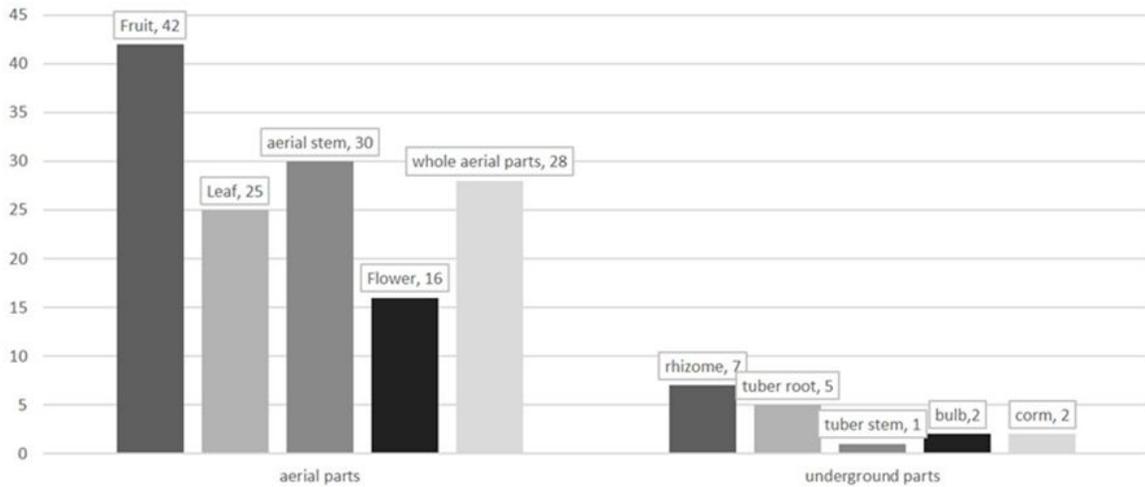


Figure 2

the diversity of plants and uses of vegetables

Fig 3 Diseases

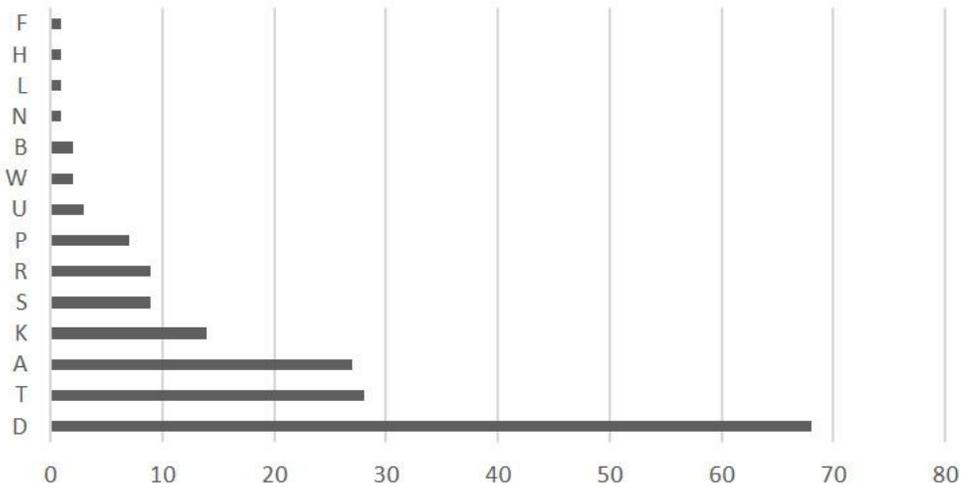


Figure 3

the local knowledge of medicinal uses and health functions of vegetables

Fig 4 Bibliographies Comparison

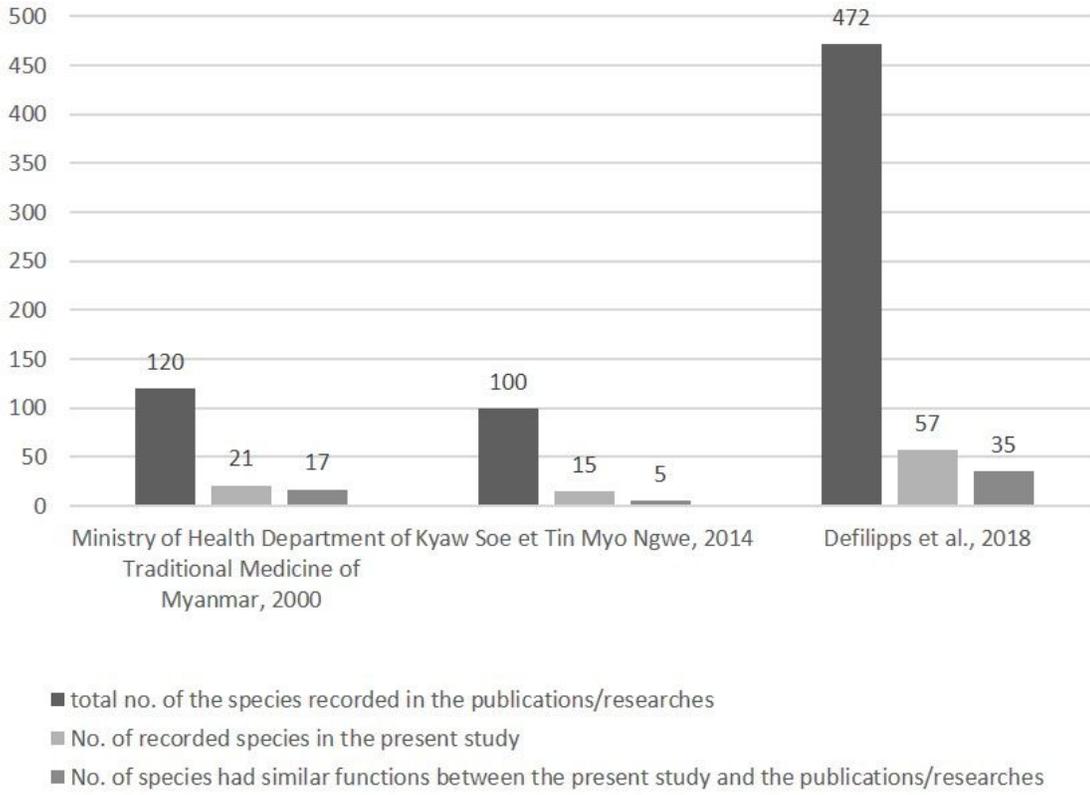


Figure 4

the traditional medicinal uses of the vegetables in publications and researches



Figure 5

Rich diversity of vegetables and typical important vegetables in local markets

Supplementary Files

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- [Appendixanddata.xlsx](#)