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Cultural Uses, Ecosystem Services, and Nutrient Profile of Flowering Quince (*Chaenomeles speciosa*) in the Highlands of Western Yunnan, China¹

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Introduction

Naxi, Tibetan, Bai, Yi, and Han communities in the Hengduan Mountain region of China's western Yunnan have an extensive history of cultivating flowering quince (*Chaenomeles speciosa* [Sweet] Nakai; Rosaceae; Fig. 1). Flowering quince is cultivated and utilized by communities for food, medicine, and as a windbreak barrier and soil protector at the edges of their fields and gardens (Gao et al. 2011). The Hengduan Mountains are characterized by limited fertile land and cultivated fields that have relatively low productivity. Socio-linguistic groups living in the area for hundreds of years have developed ecological knowledge regarding suitable plants to cultivate in order to support community wellbeing in this extreme habitat. This study presents an ethnobotanical profile of flowering quince and seeks to understand the cultural and ecosystem services it provides to communities in the Hengduan Mountain region. The main objective of this study is to understand the rationale for its traditional cultivation and to explore the potential commercial value of flowering quince.

Flowering quince is a deciduous multi-stemmed shrub 1.5 – 3.0 m tall with spiny branches and a perennial rootstock (Lu et al. 2003). It is adapted to a wide range of ecological conditions including adverse dry and cold montane terrain with soils limited in nutrients. This species is mainly distributed in dry mountain areas in temperate and subtropical areas and grows best in environments with

ample light but is tolerant of partial shade. Flowering quince is a fast-growing species that is quick to establish itself with a thriving root system and long life. This species is easy to cultivate given its disease and drought tolerant status. The thorny branches of flowering quince make it suitable as a green fence to protect home gardens and cropping fields, prevent soil erosion, and reduce wind damage. In addition, this hardy species does not require irrigation and agro-chemical input. The genus *Chaenomeles* consists of five species that originated in Southeast Asia and currently are found in China, three of which are endemic: *C. speciosa*, *C. tibetica*, and *C. sinensis* (He et al. 2015). Of these *Chaenomeles* species, *C. speciosa* has the greatest abundance in Yunnan and is the most utilized for its medicinal and edible fruit.

Flowering quince bears apple-like fruit that are 5–6 cm long and yellow-green in color. The fruit are hard with thick flesh, a strong aroma, and an astringent taste. Each fruit weighs approximately 0.5–1.5 kilograms. This species bears mature fruit in the autumn and winter three years after planting seeds; it enters its full bearing period after four to five years with its highest fruit yields after eight years of planting. Each plant can produce 35–65 kilograms of fruit per year. Four kilograms of fresh fruit can be dried to one kilogram. The fruit can be stored at room temperature for one to two months after harvest.

The fruit of flowering quince has a long history of medicinal use in the ethnopharmacopeia of

Fig. 1. Botanical drawing of flowering quince. (1) and (2) flowering quince branches, (3) fruit of flowering quince, (4) cross-section of the flower of flowering quince and, (5) cross-section of the fruit of flowering quince

China's socio-linguistic groups as well as in Traditional Chinese Medicine (TCM). It is locally

referred to as the "fruit for healthcare for longevity." Flowering quince was first recorded in the Chinese

medical volume *Ming Yi Bie Lu* (Supplementary Records of Famous Herbalists) approximately 1,800 years ago with a description of its processing and preparation including eating the fruit raw with honey, steamed, or pan-fried with honey and ginger (Peng et al. 2009). The medicinal functions of flowering quince are further mentioned in the ancient Chinese medical books “Edible Herb,” “Famous Medicinal Technology,” and “Qian Jin Prescription” (Xiang et al. 2002). This species is used for a wide range of health conditions in TCM including for hyperosteoarthritis (Zhang 2002), sciatica (Yang 2009), cervical spondylopathy (Yang et al. 2008), vertigo induced by cerebral arteriosclerosis (Wang 2002), eyelid beating symptom (Tang 2011), tinea pedis (Jiang and Liu 1996), diabetes foot and ulcers (Zhu 2010), ascites due to liver cirrhosis (Ma et al. 2007), and liver function and rheumatism (Lu et al. 2007). Pharmacological studies have found the fruit of flowering quince to have antioxidant activity (Song et al. 2007), antidiarrheal activity (Chen et al. 2007), anti-inflammatory and antiarthritic activity (Chen and Wei 2003), immunomodulatory activity (Zheng et al. 2004), antiparkinsonian activity (Zhao et al. 2008), and a broad range of antimicrobial activity (Xie et al. 2007).

The main pharmacodynamic constituents of flowering quince have been identified as oleanolic acid, ursolic acid, glycosides, and polysaccharose (Yin et al. 2006). Oleanolic and ursolic acid both have a variety of biological activities, including hepatoprotective (Jeong 1999; Xiong et al. 2004), antiparkinsonian (Zhao et al. 2008), immune enhancement (Raphael and Kuttan 2003), antitumor (Hsu et al. 1997; Huang et al. 2006), and antioxidative (Ismaili et al. 2004; Sheng et al. 2009). In addition, oleanolic acid has anti-platelet aggregation activities that can be used for hypoglycemic and hypolipidemic conditions (Tang et al. 2000). Glycosides from this species have an analgesic effect (Wang et al. 2005) and have been shown to remit adjuvant-induced arthritis in mice (Dai et al. 2003) and prevent collagenic arthritis (Zhang et al. 2004). Polysaccharose from this species activates immunocytes that improve the body's immune function (Liu and Liu 2008).

In addition to medicinal use, the fruit of flowering quince are edible; however, they are generally not suitable for eating fresh given their sour taste, unsmooth texture, and high fiber content. Several processing methods are used to transform flowering quince into a palatable food, including fruit

preservation into jams and other preserves (Yu et al. 2000), vinegar making (Zhou et al. 2005), drying (Bao 2000), and wine and other liqueur making (Liu and Pan 1999). The high pectin content of the fruit makes it particularly suitable for processing into jam. The edible function of flowering quince was affirmed by the Chinese Ministry of Health in 1996 and has been recommended by Chinese nutritionists on their top 10 nutritional food lists (Tang et al. 2000). The chemical constituents of flowering quince fruit are organic acids, amino acids, protein, carbohydrates, flavones, saponins, tannins, micronutrients, and vitamins (Long et al. 2005; Wu et al. 1996; Zhang et al. 2011).

Flowering quince is further valued for its ornamental flowers that are typically red with some cultivars ranging from pink to white. Each flower is 4.0 cm in diameter. The showy flowers have promoted its cultivation as an ornamental around the world, including throughout the eastern United States, where it grows in USDA Zones 4–9.

Research is needed to identify opportunities where traditional agro-ecological knowledge can inform modern intensive agriculture. This latter mode of agriculture is particularly unsustainable in the poor soil of the Hengduan Mountains where high inputs are necessary for productivity. In many cases, the promotion of intensive agriculture has served to restrict development of local socio-linguistic groups in the region because of the high economic investment in agro-chemicals and farming practices that are misaligned with traditional values. Research is needed to identify traditional crops that can be promoted in the region that are ecologically sustainable and have cultural and economic values for local communities as well as potential new uses. This study focuses on examining the commercial potential of flowering quince as a health food and bioenergy source through an ethnobotanical survey consisting of household interviews and a phytonutrient investigation. Findings from this study have the potential to contribute to the sustainable use and expanded economic potential of flowering quince for community development in the Hengduan Mountain region.

Methods

STUDY SITES

Participatory rural appraisal was carried out in areas where flowering quince is distributed in

Fig. 2. Distribution area of flowering quince in Yunnan Province of China. Participatory rural appraisal was carried out in the distribution area of flowering quince in Yunnan Province at the sites indicated on the map including Linglang, Yongsheng, Yulong, Dali, Yongping, Eryuan, Jianchuan, Nanjian, Yunlong, Yangbi, Baoshan, Tengchong, Lushui, Yingjiang, Dehong, Weixi, Lincang, and Puer. This study was carried out at the following two study sites: Ludian Township of Yulong County in Lijiang Prefecture and in Baozu Township of Weixin County in Diqing Prefecture

Yunnan Province of China, including Linglang, Yongsheng, Yulong, Dali, Yongping, Eryuan, Jianchuan, Nanjian, Yunlong, Yangbi, Baoshan, Tengchong, Lushui, Yingjiang, Dehong, Weixi, Lincang, and Puer (Fig. 2). From this initial survey, field sites were selected in Naxi and Tibetan communities in Lijiang and Diqing Prefectures of

Northwest Yunnan Province where flowering quince has a long cultivation history. The socio-linguistic groups in this area include Naxi, Tibetan (Khampa), Lisu, Pumi, Yi, Miao, and Bai. Specifically, fieldwork was carried out with Naxi households in Ludian Township of Yulong County in Lijiang, while interviews with Tibetan

households were conducted in Baozu Township of Weixi County in Diqing (Fig. 2). Both study site communities are relatively remote. They are each located approximately three and one-half hours from the nearest market on an unpaved road leading out of the village and connecting to paved roads. The elevation of the study sites ranges from 2,160 to 3,839 m above sea level. The annual rainfall fluctuates between 900 and 1,100 mm. Households primarily follow subsistence lifestyles farming in the surrounding alpine mountainous land where they grow buckwheat, barley, maize, rapeseed, and other alpine crops.

Household Surveys

Ten percent of households were randomly selected for interviews at each study site, including 512 Naxi informants from 121 households in Ludian Township and 138 Tibetan informants from 71 households in Baozu Township. Semi-structured interviews were conducted in Naxi and Tibetan languages, as appropriate, to gather data on the use and management of flowering quince. Survey questions included the following, among others: (1) What are all the reasons that you value flowering quince?, (2) What is the approximate area of flowering quince that your family has cultivated?, (3) Do you intercrop any species with flowering quince in your homegardens or agro-forests? If so, which ones?, and (4) What percent flowering quince under cultivation does your household consume and what percentage is commercialized? Field surveys were conducted in flowering quince cultivation areas to estimate production amounts. Fruit samples of flowering quince (*C. speciosa*) as well as other quince species used by Naxi and Tibetan households, including *C. cathayensis* and *C. tibetica*, were collected from each study site.

Field Collections

A total of 1.5 kg fresh fruits of flowering quince were collected from the two study sites in October 2011 to examine nutrients. Flowering quince samples were collected from four different altitudes including 2,800 m, 2,700 m, 2,600 m, and 2,500 m. In addition, samples were collected from four types of cultivation areas including: (1) mixed crop fields with intercropping of fruits and medicinal plants, (2) mixed crop fields with intercropping of

grains and medicinal plants, (3) medicinal plant areas, and (4) homegardens with a fence of flowering quince. Collected fruit were randomly selected, cut into pieces, and dried indoors in field dryers for further analysis. Samples were deposited at the herbarium in Kunming Institutes of Botany (KIB) in Kunming, China.

Nutrient Composition

The fruit pulp was removed for analysis of protein, vitamin C, total sugar, acid, tannins, soluble solids, crude fiber, water, and minerals (sulfur, phosphorus, calcium, magnesium, iron, zinc, copper, and manganese). Seeds were roasted and analyzed for crude fat. Samples were analyzed at the Test Center of Agricultural Products, Quality Supervision and Inspection of the Ministry of Agriculture (Kunming Prefecture, Yunnan Province, China). The following protocols were used to examine the nutrient content of samples on the basis of the Association of Official Analytical Chemists (AOAC) methods (AOAC 1984, 1990): (1) total sugar was evaluated with a direct titration assay; (2) total acid was determined by acid-base titration and potentiometry; (3) tannin (%) was determined by visible spectrophotometry; (4) soluble solid (%) was determined by refractometry; (5) crude fiber (%) was determined by a filtration assay; (6) water (%) was quantified through direct drying; (7) vitamin C content was measured by a 2, 6-dechloro-indophenol titration assay; (8) mineral content was evaluated using inductively coupled plasma-atomic emission spectrometry to quantify sulfur (S) mg/kg, phosphorus (P) mg/kg, potassium (K) %, calcium (Ca) mg/kg, magnesium (Mg) mg/kg, iron (Fe) mg/kg, zinc (Zn) mg/kg, copper (Cu) mg/kg, and manganese (Mn) mg/kg; and (9) crude fat was measured using method 920.39 of the AOAC (1990).

Results

HOUSEHOLD SURVEYS

Flowering quince is an important component of agro-ecosystems at the study sites. It is called *shengchuo* (“strong sour”) in Naxi and *shaiyao* in Tibetan. Naxi and Tibetan communities cultivate flowering quince as a green fence around crop fields and homegardens. In addition, the Naxi cultivate it

in their agro-forestry systems along with fruit trees, medicinal plants, and grain crops. Both Naxi and Tibetan communities utilize cultivated flowering quince and nearby wild populations as an edible fruit, as medicine, as a windbreak, and for ornamental purposes. Informants regard flowering quince as a low management species because it requires no agro-chemical input and little care. The main management practices are planting and harvesting. Communities harvest the fruit of flowering quince for subsistence use and increasingly for commercialization.

Informants at the study sites reported that flowering quince is valued in their fields and homegardens as a natural windbreak that prevents soil erosion with its strong root system and keeps animals away from fields and livestock are guarded with its thorny branches. Naxi and Tibetan communities at the field sites further value flowering quince because of its durability in their high altitude alpine surroundings with poor soils where there is a shortage of crops that are cold and drought resistant.

Households annually harvest 20 kg – 8,000 kg of fresh flowering quince fruit during the autumn depending on the area they manage and their preferences. Naxi households harvest four times the amount of flowering quince compared to Tibetan households at the study sites. Fruits are harvested at an elevation between 1,300 m and 2,000 m. Both males and females are active in the cultivation of flowering quince and harvest of fruit. Informants harvest the largest amount of flowering quince in autumn and winter when the fruits are mature. The fruits are regarded locally as having the highest nutritional value during these seasons.

Households primarily cultivate flowering quince at the edges of terraced fields and agro-forestry systems. Approximately 60% of flowering quince individuals at the study sites are cultivated as part of agro-forestry systems, 40% are cultivated in intercropped systems with grains, and 10% grow in monoculture stands. Within agro-forestry systems, flowering quince grows with fruit trees and crops including peach, pear, persimmon, walnut, apple, chestnut, maize, buckwheat, potato, rapeseed, cabbage, pea, radish, carrot, onion, and garlic. In addition, six medicinal plants are commonly found in these agro-forestry systems including *Gentiana robusta* King ex Hook. f., *Aconitum stapfianum* Hand.-Mazz., *Aucklandia lappa* Decne., *Platycodon grandiflorus* (Jacq.) A.DC., *Eutrema yunnanense* Franch., and *Dipsacus asper* Wall. The area represented by functional groups within these

agro-forestry systems is approximately 15% flowering quince, 20% fruit trees, and 65% other crop and medicinal plants.

All informants reported that the most prevalent use of flowering quince is as a food item followed by medicinal use. Both Naxi and Tibetan households use flowering quince fruit as preserved food, seasoning, vinegar, and wine for household wellbeing. Flowering quince is used as a seasoning for chicken and fish. Informants indicated that they utilize the largest amount of flowering quince fruits during the winter season when there is a shortage of other fruits and is also when flowering quince has the most aromatic smell. Other fruits commonly consumed at the study sites include apples, walnuts, pears, and peaches.

In addition, Naxi and Tibetan households use flowering quince medicinally for several common and varying purposes. Naxi communities use flowering quince to treat rheumatthritis, rheumatic numbness, beriberi, dysentery, abdominal and thorax distension, leg and knee pain, diarrhea, and as an antemetic. Tibetan communities use flowering quince in their traditional medical practice for treating ear disease, dyspepsia, gastrelcoma, and rheumatism.

Flowering quince is increasingly being commercialized as a food, medicine, and ornamental. Approximately 10% to 45% of flowering quince fruits are commercialized by local households at the study sites. Households earn approximately 1.5 RMB / kg (~ USD 0.24) of dried fruit and 1,500 RMB (~USD 240) per hectare. Most of the flowering quince commercialized at the study sites goes to the market for medicine and health food that is increasingly in demand in the domestic market. Large-scale cultivation of flowering quince in the Hengduan Mountain region of western Yunnan started in the 1980s following government and economic reforms. The three counties primarily involved in the cultivation of flowering quince are Dali, Lijiang, and Licang with Dali having the largest production area and the most active marketing campaign for the commercialization of flowering quince fruit (Table 1). Our survey estimates that flowering quince is distributed over an area of approximately 458.9 square kilometers throughout western Yunnan with over 40,000 households cultivating this species. It is further estimated that approximately 44% of the flowering quince area is cultivated by Han, 17% by Naxi, 16% by Bai, 15% by Yi, 4.5% by Wa, 2% by Hani, and 1.5% by Tibetans. The annual yield of

Table 1. NUTRIENT COMPOSITION OF FRESH FRUIT OF FLOWERING QUINCE COLLECTED FROM THE NAXI AND TIBETAN STUDY SITES IN NORTHWEST YUNNAN, CHINA.

Category	<i>C. speciosa</i>	<i>C. speciosa</i>	<i>C. cathayensis</i>	<i>C. cathayensis</i>	<i>C. tibetica</i>
	Naxi study site	Tibetan study site	Naxi study site	Tibetan study site	Tibetan study site
Protein (%)	0.25	0.19	0.3	0.33	0.25
Total sugar (%)	1.85	2.27	3.17	3.14	2.38
Total acid (%)	2.65	2.77	2.59	2.87	2.44
Tannin (%)	2.12	1.14	1.66	1.22	1.19
Soluble solid (%)	7.97	8.42	8.52	9.02	8.77
Crude fiber (%)	1.53	1.21	1.27	1.75	1.32
Moisture (%)	89.6	87.6	87.2	85.8	85.4
Vitamin C (mg/100g)	52.7	91.6	56.4	202.5	104.4

fresh fruits from flowering quince in western Yunnan was approximately 10 million tons in 2012 with a market share of 15 million RMB (1.5RMB/kg).

Nutrient Composition

Findings support that the rich nutrient composition of flowering quince is responsible for its wide cultivation and utilization as food by Naxi and Tibetan farmers in northwest Yunnan. Data on the nutrition composition of flowering quince fruit (*C. speciosa*) as well as the other quince species harvested, *C. cathayensis* and *C. tibetica*, show they are notable sources of vitamin C and tannins (Table 1). The content of total vitamin C from flowering quince samples ranged from 52.7 mg/100g to 91.6 mg/100g, between 56.4 mg/100g and 202.5 mg/100g for *C. cathayensis*, and 104.4 mg/100g for *C. tibetica*. The high content of tannins (1.14% – 2.12%), soluble solids (7.97 – 8.42%), and crude fiber

(1.21% – 1.53%) contribute to the hardness of the flowering quince fruit and enable its ease of transport to the market without damage. These nutrient aspects also contribute to the need for the fruit to be further processed to be more palatable. The fruit have a relatively low content of crude protein (0.19% – 0.25%) and total sugar (1.85% – 2.27%). The analyzed samples of *C. cathayensis* and *C. tibetica* had similar nutrient profiles as *C. speciosa*.

The analyzed flowering quince samples further contain a notable quantity of a variety of mineral elements (Table 2) as well as a high content of crude fat from dried seeds (Table 3). Analysis of the mineral composition of flowering quince (Table 2) shows that it is a significant source of Ca (169 mg/kg – 271 mg/kg), Zn (0.94 mg/kg – 1.07 mg/kg), Fe (1.76 mg/kg – 1.94 mg/kg), and Mg (64.2 mg/kg – 69.6 mg/kg), which all play a crucial role to support human health. Findings on the crude fat content of flowering quince seeds ranges from 26.95% to 31.74% (Table 3), indicating that it is

Table 2. MINERAL COMPOSITION OF FRESH FRUIT OF FLOWERING QUINCE COLLECTED FROM THE NAXI AND TIBETAN STUDY SITES IN NORTHWEST YUNNAN, CHINA.

Category	<i>C. speciosa</i>	<i>C. speciosa</i>	<i>C. cathayensis</i>	<i>C. cathayensis</i>	<i>C. tibetica</i>
	Naxi study site	Tibetan study site	Naxi study site	Tibetan study site	Tibetan study site
S (mg/kg)	32.4	22.9	31.8	30.3	31.3
P (mg/kg)	101	117	90.4	142	171
K (mg/kg)	0.124	0.092	0.126	0.14	0.127
Ca (mg/kg)	169	271	182	177	256
Mg (mg/kg)	64.2	69.2	54.4	69.6	75.2
Fe (mg/kg)	1.76	1.94	1.74	1.29	1.21
Zn (mg/kg)	0.94	1.07	0.9	0.93	0.78
Cu (mg/kg)	0.78	0.6	0.56	0.91	0.82
Mn (mg/kg)	0.62	0.43	0.32	0.22	0.44

Table 3. CRUDE FAT AND MOISTURE CONTENT OF DRIED SEED OF FLOWERING QUINCE COLLECTED FROM THE NAXI AND TIBETAN STUDY SITES IN NORTHWEST YUNNAN, CHINA.

Category	<i>C. speciosa</i>	<i>C. speciosa</i>	<i>C. cathayensis</i>	<i>C. cathayensis</i>	<i>C. tibetica</i>
	Naxi study site	Tibetan study site	Naxi study site	Tibetan study site	Tibetan study site
Crude fat (%)	26.95	31.74	22.58	15.73	28.22
Moisture (%)	7.3	5.2	7.1	6.9	6.8

a promising source for utilization as an alternative bioenergy plant.

Discussion

The diversified ecosystem services provided by flowering quince, coupled with its cultural association with Naxi and Tibetan communities, position this plant for expanded commercialization and contribution to local economic development in the adverse growing conditions of the Hengduan Mountains. The cultivation, use, and commercialization of flowering quince are assessed to be sustainable on the basis of cultural, economic, and ecological criteria. Flowering quince is a culturally important resource for Naxi and Tibetan communities for its role in local food systems, healthcare, and agro-ecosystems as a natural windbreak, soil protector, and green fence. Promotion of commercialization of this resource in Naxi and Tibetan communities will thus be in line with local cultural identity and practice.

Ecologically, flowering quince plays an important role as a windbreak, natural barrier, and soil protector around crop fields and agro-forests. Given the hardness of the plant in marginalized lands and its disease resistance, expanding the cultivation area of flowering quince would require low management without the economic expense and ecological threat of agro-chemical input, including fertilizers, pesticides, and herbicides. While adaptation of flowering quince to a broad range of ecological conditions makes it an attractive species, promoting its expanded cultivation in its native range would eliminate the ecological repercussions associated with invasive species. Cultivation of flowering quince is further attractive because the plant is not destroyed during fruit harvest, allowing for a renewable resource for food, medicine, ornamental, and bioenergy.

Culturally, flowering quince provides a source of food and medicine for Naxi and Tibetan communities. Medicinally, it provides treatment for a range of health conditions at the Naxi and Tibetan field sites. Flowering quince is a source of nutrition

during the winter months when produce supply is low in alpine communities of northwestern Yunnan. It is used in local cuisine in a diversity of ways, including as a seasoning, preserved snack item, vinegar, and wine.

Household surveys on the dietary value of flowering quince were validated by nutrient analysis that found samples to be rich in vitamin C, calcium, zinc, iron, and magnesium. The vitamin C values for flowering quince samples are notably higher than published values of apples, pears, peaches, lemons, and many other common fruits (Zhang et al. 2011), which points to its potential for expanded commercialization for healthcare. Vitamin C is recognized to help the body in the metabolic processes of transforming, building up resistance to disease, and for its anti-scorbutic effect (Yu 2008).

Flowering quince also has potential as a plant biomass fuel. Promising sources are characterized by wide distribution, low discharge of carbon dioxide and sulfur dioxide and abundant biomass (Peng 2011; Saxena et al. 2009; Yuan et al. 2008). They also include those plants with high oil content per seed. For example, *Camellia reticulata* is currently used for producing biodiesel in China with an oil content per seed ranging between 36% and 43% (± 0.2) (Fan 2012; Jin et al. 2012; Liu and Ma 2010). The high oil content of flowering quince makes it a candidate for further research and development.

Conclusion

Expanded commercialization of flowering quince could come from its use as both a health superfood and a bioenergy resource. It contains rich nutrients that are beneficial to human wellbeing and can be utilized as a bioenergy source. The fruit represents a particularly high source of vitamin C and polyphenols that are known for their antioxidant activity. The year-round availability as well as its long shelf life highlight its importance for food security in local communities as well as its ability to be commercialized widely. In addition, the dried seed contains a

high content of crude fat (26.95%), which suggests its utilization could extend from traditional uses to meet modern bioenergy needs.

In order to optimize cultural, economic, and ecological values of flowering quince, we recommend cultivation in diversified agro-forestry systems that meet year-round priorities of local Naxi and Tibetan communities in the Hengduan Mountains. Integrating these priorities and practices into development efforts to expand the commercialization of flowering quince can be achieved through active farmer participation in extension programs and farmer exchange systems.

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