

In-situ Conservation of Traditional Vegetable Diversity in Wa Homegardens in Southwestern Yunnan, China

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Abstract

Background: Homegardens are recognized as in-situ conservation sources of germplasm diversity to overcome homogenous germplasm problems in the industrial agriculture system; it is crucial to understand how smallholders manage their homegardens to maintain traditional genetic resources. Wa is a long-dwelling ethnic group living mainly in southwest Yunnan, China.

Traditional vegetables in homegardens management are still central to farmers' livelihoods in Wa villages. We surveyed traditional vegetables in Wa homegardens and analyzed the factors conserving traditional vegetables in the homegardens management.

Methods: The methods used in this work included semi-structured interviews, questionnaires, and field surveys. A total of 60 households through purposive sampling in three townships, 6 villages were surveyed. We documented ethnobotanical information on local name, edible methods, edible parts of traditional vegetables maintained in Wa homegardens. Plant species cultivated in Wa homegardens were identified according to Flora of China.

Results: Fifty-five traditional vegetable varieties and 36 hybrid vegetable varieties in the homegardens were recorded. Among all the villages, 23 ± 6 (average \pm S.D.) traditional vegetable varieties per homegarden and 9 ± 3 (average \pm S.D.) introduced vegetable varieties per homegarden were recorded. 78% of households choose to store the local seeds themselves, with a further 9% of households' seed supplies coming from neighbors and relatives, other 13% of households choose to purchase local seeds in the markets. In 83% of families, the female head holds the main responsibility for decision making for traditional vegetables planted in homegardens; in 10% of families were male head household to take responsibility for decision-making, and a small percentage which is 2% is determined by the elderly. 5% of families will make decisions jointly between both male and female household heads.

Conclusions: This study demonstrated that rich traditional germplasm diversity is harbored in the Wa homegardens because of Wa communities' unique culture and traditional knowledge, which is practiced daily using homegrown food plants. Local vegetable seed saving and sharing systems can help maintain the germplasm diversity in the Wa community's homegardens. Wa homegardens can be a practical solution to protect the traditional germplasm diversity and maintain a lifestyle with traditional culture.

Background

Traditional vegetables are cultivated varieties arising through a long history of selection and cultivation in places like homegardens. 'Traditional' vegetables are defined as those 'indigenous or exotic species which, due to prolonged use, have become part of the culture of a community[1]. As the world's population continues to grow, high malnutrition rates, insufficient energy sources, and a lack of essential nutrients, like vitamins, continue to be of serious concern [2]. The urgent need for food security and nutrition requires dietary diversity, particularly vegetables, for health [3, 4]. [2]Traditional vegetables have considerable commercial value and high market potential to contribute the household income [5].

However, traditional vegetables as a valuable source for food and nutritional security are underutilized and under-represented in the global conservation system for plant genetic resources [6–8]. Due to the expansion of the global market economy and modernization of agriculture, high yield hybrid vegetables have become more popular and valued. However, the diversity of traditional vegetables are threatened with extinction [9, 10].

Homegardens are recognized as a source of high vegetable germplasm diversity, which can be essential to overcome food-security problems, such as loss of food sources from rapidly spreading diseases associated with homogenous germplasm in the industrial agriculture system [11–13]. Homegardens possess many attributes to make economic, social, and ecological contributions to sustainability. Homegardens provide edible vegetables, medicinal plants, ornamental plants, firewood crops, and fodder without negatively causing the resource shortages for self-sufficiency and social values underpinning and contributing to cultural diversity [14, 15]. [17, 18] Furthermore, traditional homegardens are more sustainable and adapted to local demands by planting traditional varieties and using traditional management knowledge [16, 17].

The diversity in homegardens can be affected by the interactions with spatial, environmental, demographic, social, economic, and cultural factors to influence agricultural practices management. Diversity in homegardens is influenced by the size of communities, ethnicity of residents and geographical position away from the town [18]. Also, elevation, location, homegarden size, distance to market, additional land ownership (outside the homegardens) and livestock ownership are significant predictors of crop diversity [19]. Besides, a household's family structure is associated with the diversity of plants of homegardens [20]. Ancestor worship and dietary culture could be the vital reasons for farmers to keeping and cultivated local vegetables [21]. The roles of traditional knowledge to protect genetic diversity have been acknowledged [22–24], and it has much potential to help design more effective conservation for agrobiodiversity, especially for traditional vegetables [25]. Gender is also another factor that influences the crop diversity in homegardens [26], previous study has shown that the awareness of the importance of organic vegetables planted in the homegardens has been increased by women [27].

China has a long history of traditional vegetable cultivation in homegardens, maintaining this vegetable cultivation [28, 29]. Studies have shown homegardens can be a source of germplasm bank for the conservation of local varieties [30–32]. [35] In southwest China, homegardens are small-sized agroecosystems and provide an on-farm conservation strategy consistent with household socio-economic characteristics [33–36]. Wa people is one of the 55 ethnic minorities in China. Wa people mainly inhabit the mountain areas called “Wa mountains” in the southwest of Yunnan. The Wa people speak the Wa language and do not have written words in history. The Wa villages are located on the hillside, and the traditional houses were built with thatch, bamboo, and timber. Each house has a fire pit inside to cook food and keep the house warm. Their staple foods are rice, corn, and buckwheat. The traditional belief of Wa people is animism, and they hold nature worship, ancestor worship, animal and plant worship [37]. The Wa mainly lived on abundant plant resources in the mountains and forests near the villages; they practiced swidden agriculture, hunting, and gathering activities. Due to their long history

of interacting with the plant resources around the living environment and crop farming practices, Wa people have developed various dietary cultures and traditional specialties[21, 38].

This study demonstrates traditional vegetable diversity and the factors of Wa households conserving traditional vegetable resources in the homegardens in Wa areas. We address three key questions: (1) What traditional vegetable varieties do the households prefer to plant in their homegardens? (2) who does decision-making for homegarden management in the household? Moreover, (3) Why do households continually plant traditional vegetables in their homegardens? We argue that Wa homegarden management is a promising approach for conserving traditional vegetable resources to keep dietary diversity and self-sufficiency.

Methods

Research area

The research area lies in the mountainous region of the southern part of the Nu Mountains at the border with Myanmar in the southwest Yunnan province of China, located between the west of Lancang River and the east Salween River (Fig. 1). The region embraces a diverse ethnic composition, including Wa, Lahu, Dai, and 31 other ethnic minorities. This area, traditionally known as the “Wa Mountains”, straddles the tropic of Cancer and has a subtropical climate with mild weather conditions. Affected by the Indian Ocean's warm and wet airflow, rainfall is relatively abundant. The climate is also affected by the three-dimensional characteristics of the topography in this mountainous region [38]. Cangyuan County is located between 98°52'- 99° 43'E, and 23°04'- 23° 30'N. Cangyuan belongs to the subtropical monsoon climate with a mild and wet climate. The average annual sunshine hours are 1862.5 hours. The annual average temperature is 17.7°C, and the annual average rainfall is 1747.2mm. Ximeng County is located between 99°18'- 99° 43'E and 22° 25' -22° 57'N. It belongs to a subtropical marine monsoonal climate, affected by the warm and humid southwest of the Bay of Bengal. The annual average temperature is 15.3°C, and the average annual rainfall is 2758mm, which is the highest in Yunnan province. The highest altitude in this territory is 2458.9 meters, and the minimum altitude is 590 meters. Due to this climate, the vegetation in those two counties is plentiful and diverse, with 37% of the forest coverage rate.

Sampling and data collection

Data were collected from May 2015, December 2015, May 2017, and December 2019 in six villages in Cangyuan Wa Autonomous county and Ximeng Wa Autonomous County. Dazhai village, Xiaozhai village and Banjing village are in Zhongke Town, Ximeng county. Yangluo village is in Mengsuo town, Ximeng county. Heling and Paipa villages are in Nuoliang town, Cangyuan county (Table 1). The six representative villages are mainly inhabited by Wa ethnic groups, located far from the county centre, and they were selected through discussions with local elders and village heads in an initial reconnaissance visit [39]. With the help of local farmers, agricultural bureau, and professional agricultural technology

staff from the agricultural vegetable station, 60 participants (52 males and 8 females) were sampled through a purposive sample approach [40], following the village heads' advice to identify the key informants. The interviewed households accounted for 10% of total households in each village. For reference, the interviewees' consent is based on households' availability and interest.

Table 1
Characterization of six Wa villages

Village	Ximeng County			Cangyuan County		
	Zhongke town			Mengsuo town	Nouliang town	
	Dazhai	Xiaozhai	Banjing	Yangluo	Heling	Papai
Geographic location	99°36' E, 22°47' N	99°36' E, 22°47' N	99°36' E, 22°43' N	99°40' E, 22°39' N	99°19' E, 23°12' N	99°22' E, 23°18' N
Altitude (m)	918	862	802	1173	1694	1860
Distance from the county town/seat (km)	27.3	29.3	14.8	17.4	40	45
Number of households	136	138	83	570	62	270
Main industry	Crop farming, breeding	Crop farming				

The 60 households were considered for both individual interviews and garden inventories. For the individual interview, we collected the socio-demographic information of respondents, including age, gender, and education level were recorded [41] (Table 12). Following the age categorization, 46.67% of the informants were young people (21–40 years old), 45.00% were middle-aged (41–60 years old) and the remaining 8.33% were the elderly (age ≥ 60 years old). 86.67% of informants were male. Regarding education level, 5.00% were uneducated, 51.67% attended primary school, 38.33% attended middle-high school, and 5% attended high school or more.

We defined the “traditional” vegetables should be the heirloom crops, local and culturally adopted, and handed down from generation to generation [1]. And the introduced or exotic vegetables are the vegetables being planted in recent 10 years. Homegardens inventories were conducted to identify the traditional vegetable and introduced vegetables planted in the homegardens [39]. The semi-structured interview included documentation of local names, Wa names, edible parts, edible methods of the traditional vegetables they planted in the homegardens [24, 35]. Structured questionnaire forms were assigned to participants and consisted of three main parts. The first question aimed to determine the characteristics of homegardens including size and cultivated varieties. In the second part, seed management and sourcing, self-consumption from homegardens, and the gender of the responsibility for homegarden management were considered. In the last parts, the threats and conservation issues were

identified. The nomenclature of all plants reported in our study follows the *Flora of China*. Traditional vegetable variety resources are jointly identified by local farmers, agricultural bureau, and agricultural vegetable station professional agricultural technology staff. Data obtained were triangulated to ensure reliability and validity [42].

Table 2
Sociodemographic characteristics of participants

Category	Gender		Age			Education level			
	Male	Female	21–40	41–59	≥ 60	Illiteracy	Primary School	Middle school	High school
Dazhai	10	0	5	3	2	0	4	6	0
Xiaozhai	6	4	6	4	0	1	7	2	0
Banjing	8	2	4	5	1	2	5	3	0
Yangluo	10	0	3	6	1	0	6	4	0
Heling	10	0	6	4	0	0	4	4	2
Papai	8	2	4	5	1	0	5	4	1
Quantity	52	8	28	27	5	3	31	23	3
Proportion (%)	86.67	13.33	46.67	45.00	8.33	5.00	51.67	38.33	5.00

Data analysis

Replies from participants were organized according to vegetables, management, and factors from a thematic analysis of the interviews[43]. Those included why traditional vegetable resources are continually planted in the homegardens; several themes encompassing social and cultural changes emerged from this analysis. Traditional vegetable information collected from 60 respondents was counted to identify the most important varieties in homegardens. Vegetables were counted as distinguishable units rather than as species or varieties [1].

Relative frequency of citation (RFC):
$$RFC = \frac{FCs}{N}$$

This parameter refers to the ratio of the number of respondents who mention a particular traditional vegetable cultivar (i.e., the frequency of citation, FC) to the number of all respondents participating in the survey (N). The larger the RFC, the more important and valuable the traditional vegetable is in the homegardens [44, 45].

Result

Diversity of traditional vegetables in Wa homegardens

A total of 91 vegetable varieties were recorded from the six villages, 55 traditional vegetable varieties, belonging to 11 families and 25 genera, were recorded in the homegardens (Table 3). Out of the total traditional vegetable varieties, the largest number of traditional vegetables belonged to Cucurbitaceae (10 varieties, 18.18%), Solanaceae (10 varieties, 18.18%), Brassicaceae (7 varieties, 12.73%), and Liliaceae (7 varieties, 12.73%) (Fig. 2). And other 36 introduced vegetables were investigated in the study area. Among all the villages, 23 ± 6 (average \pm S.D.) traditional vegetable varieties per homegarden and 9 ± 3 (average \pm S.D.) introduced vegetable varieties per homegarden were analyzed. Villages from Dazhai, Xiaozhai, Banjing, Yangluo, Heling, and Papai cultivated more in traditional vegetables than in introduced vegetables (Fig. 3).

The RFC value calculated in this study ranged from 0.02 to 1. For each traditional vegetable variety, the higher the RFC value, the more frequently it was planted by local Wa villagers in the homegardens, and the more important and valuable it was in the Wa community. The most frequent vegetable varieties encountered in the homegardens were *Allium fistulosum*, *Allium tuberosum*, *Amaranthus paniculatus*, *Brassica chinensis*, *Capsicum frutescens*, *Nepeta cataria*, and *Sechium edule*. These 7 traditional vegetables cultivated by 100% of the households are essential plants in homegardens for edible use. For example, *Amaranthus paniculatus* has been widely planted in Wa homegardens owing to the feature of drought resistance, tolerance to barren soil, high yield, and no plant diseases or insect pests. *Allium fistulosum*, *Nepeta cataria*, *Allium tuberosum*, and *Capsicum frutescens* are used as spices in traditional food, which reflected that Wa households are selecting and planting local spicy vegetables, to be used as a seasoning, in the homegardens.

Table 3
Traditional vegetables and their uses in Wa homegardens

Scientific name	Local name	Wa name	Family	Edible parts	Edible methods	RFC
<i>Allium chinense</i>	Jiao tou 韭菜	Gong de mo	Liliaceae	Bulb	Spice	0.38
<i>Allium fistulosum</i>	Pake da cong 青葱	De mo	Liliaceae	Whole plant	Spice	0.12
<i>Allium fistulosum</i>	Xiao xiang cong 小香葱	De mo a mu	Liliaceae	Whole plant	Spice	1.00
<i>Allium sativum</i>	Bai pi suan 蒜	De ha	Liliaceae	Bulb	Spice	0.53
<i>Allium sativum</i>	Yongguang da suan 永光大蒜	Gong de ha din	Liliaceae	Bulb	Spice	0.05
<i>Allium hookeri</i>	Pie cai 薹菜	De ga	Liliaceae	Root, flower	Spice	0.62
<i>Allium tuberosum</i>	Xi ye jiu cai 西洋韭菜	De ga bie te	Liliaceae	Leaf	Fry	1.00
<i>Amaranthus paniculatus</i>	Yi mi cai 苋菜		Amaranthaceae	Tender leaf and stalk	Fry, Boil	1.00
<i>Benincasa hispida</i>	Lao mian dong gua 老绵冬瓜	Bie lan	Cucurbitaceae	Fruit	Fry	0.48
<i>Benincasa hispida</i>	Yuesong dong gua 月送冬瓜		Cucurbitaceae	Fruit	Fry	0.40
<i>Brassica chinensis</i>	Zi qing cai 紫青菜		Brassicaceae	Leaf, stalk	Fry, Boil	1.00
<i>Brassica chinensis</i>	Da qing cai 大青菜	Di ke lao te	Brassicaceae	Leaf, stalk	Fry, Boil, Pickling	0.48
<i>Brassica chinensis</i>	Wa qing cai 瓦青菜		Brassicaceae	Leaf, stalk	Pickling	0.90
<i>Brassica chinensis</i>	Yuan qing cai 圆青菜	Di ke lao	Brassicaceae	Leaf	Pickling	0.82
<i>Brassica pekinensis</i>	Pake bai cai 排骨菜	Di ke lao ben	Brassicaceae	Leaf, stalk	Fry, Boil	0.47
<i>Brassica pekinensis</i>	Nanguai bai cai 南淮白菜		Brassicaceae	Leaf, stalk	Fry, Boil	0.28

* cultivated and wild species

Scientific name	Local name	Wa name	Family	Edible parts	Edible methods	RFC
<i>Capsicum annuum</i>	Chao tian jiao 朝天椒		Solanaceae	Fruit	Spice	0.63
<i>Capsicum annuum</i>	Xiaozhai la 小寨辣	Meng ke meng xiao	Solanaceae	Fruit	Spice	0.22
<i>Capsicum annuum</i>	Talang la jiao 棠辣		Solanaceae	Fruit	Spice	0.02
<i>Capsicum frutescens</i>	Xiao mi la 小米辣	Meng he bie te	Solanaceae	Fruit	Spice	1.00
<i>Capsicum frutescens</i>	Bai pi xiao mi la 白皮小米辣	Meng he beng	Solanaceae	Fruit	Spice	0.77
<i>Capsicum frutescens</i>	Lao shu la jiao 老树辣	Meng he bing	Solanaceae	Fruit	Spice	0.02
<i>Capsicum frutescens cv. Shuanlaense</i>	Shuan shuan la 涮涮辣		Solanaceae	Fruit	Spice	0.02
<i>Colocasia esculenta</i>	Zi yu 紫芋	Gi ao	Araceae	Corm	Fry, Soup	0.05
<i>Colocasia esculenta</i>	Banshuai yu tou 半水芋头		Araceae	Corm	Fry	0.38
<i>Colocasia esculenta</i>	Di shui yu 地水芋*		Araceae	Leaf, stalk	Soup, Spice	0.90
<i>Colocasia esculenta</i>	Naka da ma yu 纳卡大玛芋		Araceae	Corm	Soup	0.02
<i>Coriandrum sativum</i>	Xi ye yan sui 芫荽	De gei	Apiaceae	Tender leaf and stalk	Boil, Salad, Spice	0.85
<i>Cucumis sativus</i>	Di huang gua 地黄瓜	Gai	Cucurbitaceae	Fruit	Salad	0.95
<i>Cucurbita moschata</i>	Jin gua 金瓜		Cucurbitaceae	Fruit, tender leaf, flower	Fry	0.28
<i>Cucurbita moschata</i>	Lao mian nan gua 老面南瓜	Bei	Cucurbitaceae	Fruit, tender leaf, flower	Fry	0.22
<i>Cucurbita moschata</i>	Xiao nan gua 小南瓜	Bei	Cucurbitaceae	Fruit, tender leaf, flower	Fry	0.55

* cultivated and wild species

Scientific name	Local name	Wa name	Family	Edible parts	Edible methods	RFC
<i>Dioscorea batatas</i>	Zi shan yao 薯		Dioscoreaceae	Tuber	Boil	0.03
<i>Dioscorea batatas</i>	Shan yao 薯	Hao ang	Dioscoreaceae	Tuber	Boil	0.65
<i>Dioscorea batatas</i>	Xi shan yao 薯		Dioscoreaceae	Tuber	Boil	0.32
<i>Foeniculum vulgare</i>	Hui xiang 茴香	Di gei lao	Apiaceae	Whole plant	Spice	0.03
<i>Lagenaria siceraria</i>	Hu lu 葫芦	Ci nie	Cucurbitaceae	Tender leaf	Fry	0.07
<i>Luffa cylindrica</i>	Si gua 丝瓜		Cucurbitaceae	Tender fruit	Fry	0.27
<i>Lycopersicon esculentum</i>	Xiao fan qie 西红柿	Meng ge li xia	Solanaceae	Fruit	Salad	0.35
<i>Eryngium foetidum</i>	A Wa yan sui 蕺菜*	De gi ga pu	Apiaceae	Whole plant, tender leaf and stem	Spice	0.30
<i>Mentha haplocalyx</i>	Bo he 薄荷*	De ba ha	Lamiaceae	Tender stem tip, leaf	Spice, Fry	0.45
<i>Momordica charantia</i>	Menge ku gua 苦瓜	Dong dai	Cucurbitaceae	Fruit	Fry, Salad	0.02
<i>Nepeta cataria</i>	Jing jie 荆芥		Lamiaceae	Tender leaf	Spice	1.00
<i>Pachyrhizus erosus</i>	Hong shu 红薯	Ha na yang	Leguminosae	Bulb	Fry	0.05
<i>Perilla frutescens</i>	Bai su 白苏		Lamiaceae	Leaf, stalk	Spice	0.02
<i>Perilla frutescens</i>	Hei su 黑苏		Lamiaceae	Leaf, stalk	Spice, Salad	0.02
<i>Pisum sativum</i>	Lao zhai wan dou 豌豆	De dou	Leguminosae	Seed	Fry	0.23
<i>Pisum sativum</i>	Wangya wan dou 豌豆		Leguminosae	Seed	Fry	0.20
<i>Pisum sativum</i>	Hong wan dou 红豆		Leguminosae	Seed	Fry	0.17

* cultivated and wild species

Scientific name	Local name	Wa name	Family	Edible parts	Edible methods	RFC
<i>Raphanus sativus</i>	Bai luo bo 白萝卜	Meng bie te	Brassicaceae	Root, leaf	Pickling	0.03
<i>Sechium edule</i>	Fo shou gua 佛手瓜		Cucurbitaceae	Tender stem tip, flower, fruit	Fry	1.00
<i>Solanum melongena</i>	Bai qie 白茄		Solanaceae	Fruit	Fry	0.23
<i>Solanum melongena</i>	Zi qie 紫茄		Solanaceae	Fruit	Fry	0.67
<i>Vigna unguiculata</i>	Dou jiao 豆角	Bai	Leguminosae	Tender pod	Fry	0.55
<i>Zingiber officinale</i>	Huang jiang 黄姜	Si gei	Zingiberaceae	Root stock	Spice	0.90
* cultivated and wild species						

The edible methods for traditional vegetables are various, including fry, boil, salad, or spicy seasoning. Those traditional edible methods objectively require Wa gardeners to grow more vegetables to meet daily dietary needs. Among all the recorded 55 traditional vegetable cultivars, the edible plant parts of traditional vegetables were divided into nine categories: fruit, leaf, stalk, bulb, flower, seed, root, whole plant, and pod (Table 4). Fruits (20 species, 28.17%), mainly in the Cucurbitaceae and Solanaceae families, are the most commonly used plant parts for nutrition. For 19 species (26.76%), the tender leaf is the part for edible usage by Wa people. Households used tender leaves of traditional vegetables in multiple cooking methods, such as seasoning, frying, boiling, and salad. For five species (7.04%) of 55 cultivars, traditional food needs to use the flower as edible parts. This phenomenon showed that the anthophagy (flower-eating) culture is rich and diverse among Wa villagers.

Table 4
Numbers of species per edible plant part

Edible parts	Number of species	Percentage
Fruit	20	28.17%
Leaf	19	26.76%
Stalk	10	14.08%
Bulb	7	9.86%
Flower	5	7.04%
Seed	3	4.23%
Root	3	4.23%
Whole plant	3	4.23%
Pod	1	1.41%

Traditional vegetables planted in homegardens were used mostly for self-consumption and fulfilling the owners' needs. The number of households who cultivated vegetables in homegardens for self-consumption was relatively high (Fig. 4). Thirty-three out of 60 households which accounted for 55% of households use 80%-100% of their vegetables. 13% of households have achieved self-sufficiency in the proportion of 50%-80% of their cultivated vegetables in the homegardens. 15% of households are self-sufficient in percentages of 20%-50% of cultivated vegetables in the homegardens. Only 17% of 10 households use 0–20% of their cultivated vegetables in the homegardens. Vegetables planted in homegardens were used mostly for self-consumption and to fulfill the needs of the owners. Traditional vegetables are primarily used for the household's diet but are increasingly being used to generate cash income for several families. According to the interviewees, sometimes the surplus from the consumption would be sold to increase supplementary income for the families.

Seed sourcing and management

The storage and protection of seeds are an essential part of the traditional knowledge related to crops. Traditional seeding and breeding methods can promote the protection and inheritance of local vegetable germplasm resources. Among all the traditional vegetable seeds sources, about 78% of the total 60 household depend on maintaining and storing the local seeds themselves, with a further 9% of households' seed supplies coming from neighbors and relatives. 13% of households choose to purchase local seeds in the traditional markets (Fig. 5). According to the interviews, households in Wa villages primarily use local storage methods to conserve the seeds of traditional vegetables planted in their homegardens the next year. Local seed storage practices are simple. The seeds will be hung above the

fireplace where households cook the meals every day. The purpose of this action is to keep the seeds directly in a dry and ventilated place to prevent mildew and to prevent predation from insects. The selection of crop seeds for saving is based on colour, food quality, resistance to environmental stress, yield, and so on. Because of the simple breeding and selection methods of seeds, traditional vegetable landraces such as melons, beans, and peppers, which are easily harvested, are better preserved.

Seed exchange system occur within the villages and seeds are also exchanged outside Wa communities. When a household plants vegetable that have excellent characters such as color, quality or resistance to insects, neighbors, and relatives can ask for an exchange with their local crop seeds. In this way, local people have a positive, regular and reciprocal exchange seed system in the local areas. Excellent local vegetable landraces are selected from generation to generation, which is conducive to the preservation and development of traditional vegetables. The exchange between villages and towns occurs through traditional markets—farmers sell local traditional vegetable seeds in traditional markets. About 13% of households purchase local seeds in the traditional markets. Some farmers sell local traditional vegetable seeds, which are selected with better quality and set the price themselves. Like many of the local communities, seed exchange is not the main mechanism for seed acquisition in the Wa communities, with most seeds coming from each households' own storage systems. In that context, it is not surprising that, although active, the traditional seed exchange methods are fragmented and decentralized.

The exchange between villages and towns occurs through traditional markets—farmers sell local traditional vegetable seeds in traditional markets held for a long time. However, while the local family's economic conditions gradually improved, seed management for traditional vegetables has been under threat of loss. Local farmers started to stop preserving traditional seeds and choose to go to the seed stores to buy modern hybrid seeds. Unlike in the villages' traditional market, seed stores in the agriculture market now only provide modern hybrid-seeds for farmers. One of the seed dealers said: *"Farmers now prefer to buy modern seed because of the high production when they have enough money."* (Interview, 16th December 2015). This development will increase the homogeneity of vegetables planted in homegardens, consisting primarily of modern hybrid varieties of vegetables in the future. Meanwhile, from interviews we gathered that approximately 80% of the modern hybrid varieties of vegetable seeds could not be retained and sown. Farmers continuously have to buy new varieties of vegetable seeds frequently every year. This cycle's consequence is that local farmers lose the traditions of seed selection and breeding of vegetables in their homegardens unconsciously without realizing it.

Gender relation for homegardens management

In the study areas, 83 % of families were female household heads who have the right to make decisions about what kinds of vegetables will be planted in the homegardens. Male household heads account for 10% responsible for decision-making, and a small percentage which is 2% is determined by the elderly. 5% families will make decisions jointly between both male and female household heads. When it comes to seed selection and breeding, female households take more responsibility (88%). Male household heads

account for only 10% of those responsible for the management of the gardens, less that for making decisions (8%). (Fig. 6). The proportion of male household heads involved in garden management and with responsibility for distribution of vegetable varieties, and for preservation and cultivation, is smaller than the female household head.

Factors influence traditional vegetables and relevant traditional knowledge in the homegardens

The participants addressed five main factors for continued cultivation and selection of traditional vegetables in the homegardens: good taste (73.33%), honoring their ancestors through maintaining their traditions (46.67%), low cost (16.67%), low planting requirements (10.00%), and cultural festivals (1.67%) (Fig. 7).

Good taste is the fundamental reason for Wa villagers to keep planting traditional vegetables and preserving traditional knowledge in homegarden management. In Wa villages' view, traditional vegetables commonly have a more robust flavor than the modern hybrid ones, which is the main reason for traditional vegetables being used in their daily meals. Besides, Wa farmers believed that many traditional vegetable varieties have adapted to local soil and climatic conditions over these millennia of cultivation and have superior traits or good palatability.

Nearly half of the respondents believed that keeping planting traditional vegetables is critical to honor and respect their ancestors. Wa people have ancestor-worship consciousness; they value the traditional vegetable varieties germplasm as wealthy cultivated through generations and generations back to their ancestors.

16.67% and 10.00% Wa villagers, respectively, choose low planting costs and requirements because they will not give up planting traditional vegetables in the homegardens. For example, *Allium fistulosum* has a strong pungent spicy taste and a high resistance to disease and is easily cultivated. These features help Wa villagers save the workforce and financial resources for managing their vegetable gardens. Local people also prefer to grow traditional varieties using their seed and without fertilizers in their homegardens. Even though the modern hybrid vegetables can bring higher production, in the meantime they would have to continuously spend more money for vegetable seeds and fertilizer on the market. Resource input and outcomes are not proportional in such small systems; one of the farmers said:

“The traditional vegetables are easier to manage in homegardens, we don't need to spend too much time on pest control and fertilization with traditional vegetables, but as for modern vegetable varieties, they are easily threatened by pests and diseases, and we need to spend time spraying pesticides and applying chemical fertilizers to achieve high yields. It's not always worth the effort.” (Interview, 3rd August 2015)

1.67% of the respondents mentioned that culture and festivals make traditional vegetables vital in Wa custom. Although these traditional vegetables only account for a small proportion, each has its unique

characteristics and should not be ignored. For instance, Wa people have the custom of eating *Brassica chinensis* as a traditional dish during the New Year to bless the whole family for the coming year. *Colocasia esculenta* (Di shui yu) and *Eryngium foetidum* (A Wa yan sui) are the essential seasonings due to a particular taste for traditional Wa dish “chicken rice porridge” which is a cultural custom for Wa families to host guest and celebrate festivals.

Discussion

Our study demonstrated a great diversity of traditional vegetables in Wa homegardens represented by a total of 91 vegetable varieties. [38, 42]55 traditional varieties were maintained in homegardens. The local community has a wide variety of choices and uses of vegetables from many families and different genera in the homegardens. Such diversity reflects both the rich germplasm biodiversity cultivated by Wa households and the complexity of traditional dietary habits in the Wa community. Wa homegardens provide households with fresh, diverse vegetable supplies, improving their self-sufficiency capacity while conserving in-situ genetic diversity. The homegardens’ locations are closed next to the households’ houses, and this closing distance allows Wa families to plant and pick-up vegetables more accessible.

The preservation and sustainable use of traditional crop germplasm resources is the basis for ensuring the inheritance of relevant ethnic and cultural practices [46]. Dietary diversity is significant factor for Wa people to keep cultivating high diversity of vegetables in their homegardens. Wa people’s culinary culture require mixing a lot of vegetables and meat to make the dishes delicious and nutritious, which fostered traditional knowledge of various edible methods for edible parts. Demand for traditional dishes keeps some essential vegetable varieties preserved well. For example, they prefer to eat a traditional dish, Chicken Rice Porridge, which is made by using fennel, tabasco pepper, mint, garlic, spring onion, cilantro, *Allium hookeri*, chicken and rice. This dish is served when hosting guests and friends to show great respect, reflecting the cultural links between people and high crop diversity in the Wa society. Also, the preference of “spicy food” custom maintains pepper varieties in the homegardens over history. For pepper varieties in this region, seven varieties have been found in the homegardens.

The pursuit for health also promotes the diversity of vegetables used by Wa people. The traditional knowledge of health care through a daily diet rich in vegetables is important [47]. The daily Wa diet thus provides multiple functions, including nutrition supply and health care knowledge. For example, the tender leaf of *Acanthopanax trifoliatum*, which is “Daex giam” in Wa language, is usually used as a salad or traditional sauce “*Sapie*”, and it has an appetizing medical function. It shows that local people have a comprehensive and in-depth understanding of plant resources’ choice and have rich traditional knowledge of using traditional vegetables. [52][53]

Seed systems are an essential part for enhancing community resilience as seed security has several direct links to food security[48, 49]. The circulation of seed among farmers is central to agrobiodiversity conservation and dynamics [50]. Local seed supply enables local reproduction of the seed by farmers themselves, using local seed selection, production and conditioning practices [51]. All of these practices

depend on the ongoing transmission of traditional knowledge about seeds across generations. Local Wa people have a positive, regular, and reciprocal exchange seed system in the local areas. Excellent local vegetable varieties are selected from generation to generation, conducive to preserving and developing traditional vegetables. The seed exchange is not the primary mechanism for seed acquisition in the Wa communities, with most seed coming from each households' storage systems. In that context, it is not surprising that, although active, traditional seed exchange methods are fragmented and decentralized.

Homegardens are generally managed by an individual or a couple of family members, mainly the female heads of households. And women in one study were found to be aware of home-garden conservation to conserve the agro-biodiversity of homegardens.[52]. [59, 60]In the families of this study, women are generally responsible for planting and managing vegetables, selecting breeding and breeding, and the knowledge of traditional vegetable cultivation and retention is well preserved among female groups. Women in the Wa family are mainly responsible for the cultivation of vegetables in homegarden management. These findings add weight to previous studies that have identified the significant positive influence of women on the use, management and conservation of biodiversity through their roles in seed selection, seed saving and use of wild plants for food and medicines [53, 54].

Nevertheless, rapid economic and social changes and the penetration of foreign cultures are challenging the ongoing maintenance of traditional vegetables. The respondents mentioned that economy has developed rapidly in recent years, and the income of farmers has increased notably. This opportunity for higher wages pulls farmers towards urban labor and large-scale rural agricultural development has significantly reduced the rural labor force. Instead of being satisfied with the self-sufficient traditional agricultural-production lifestyle, more and more young people choose to go out to work or engage in other industries, which results in the gradual decline of cultivation of traditional. More and more households choose to plant introduced vegetables for higher yield compared to traditional vegetables. Either of these will result in the gradual disappearance of a large number of traditional vegetable varieties [55].

Conclusions

High traditional vegetable diversity which is a total of 55 traditional vegetable varieties was found in the homegardens. This study proves that high traditional vegetable diversity is maintained grown in homegardens by households in the rural villages in Wa communities in southwestern China. The continued planting and use of traditional vegetables from diverse seed sources in homegardens contribute to germplasm diversity conservation. Households in homegardens maintain and protect the diversity of traditional vegetables through their seed management systems, both saving and exchanging seeds. The cultural preference for a high vegetable diet among the Wa people plays a positive role in the protection and utilization of traditional vegetable resources—vegetables which are better tasty were kept being cultivated in homegardens. Our results reinforce the shreds of evidence that maintaining homegardens can be a practical in-situ conservation solution to protect traditional resources. Policymakers should take homegardens into land planning consideration for rural communities to keep the small-scale agriculture functioning and support encourage farmers to keep homegardens for

agrobiodiversity in-situ conservation, protection of traditional varieties, and traditional knowledge held by ethnic people in the local and communities.

Declarations

Ethics approval and consent to participate

All informants gave verbal consent for the information they provided to be shared for academic purposes only, in accordance with the ethical standards adopted by the International Society of Ethnobiology (2008).

Consent for publication

Not applicable.

Availability of data and materials

All data generated or analyzed during this study are included in this published article.

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Conflict of Interest

The authors declare that they have no conflict of interest.

Authors' contributions

Hua Shao as the principal researcher conducted the field research and data analysis and drafted the manuscript. Dr. Dayuan Xue and Dr. Jingbiao Yang as supervisors initiated and provided oversight to the study and input in its planning and provided the ethic and cultural advice based on his rich experience and knowledge. Dr. Rosemary Hill revised the English. Dayuan Xue, Jingbiao Yang and Rosemary Hill carefully revised the manuscript. All authors reviewed and approved the final manuscript.

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Figures

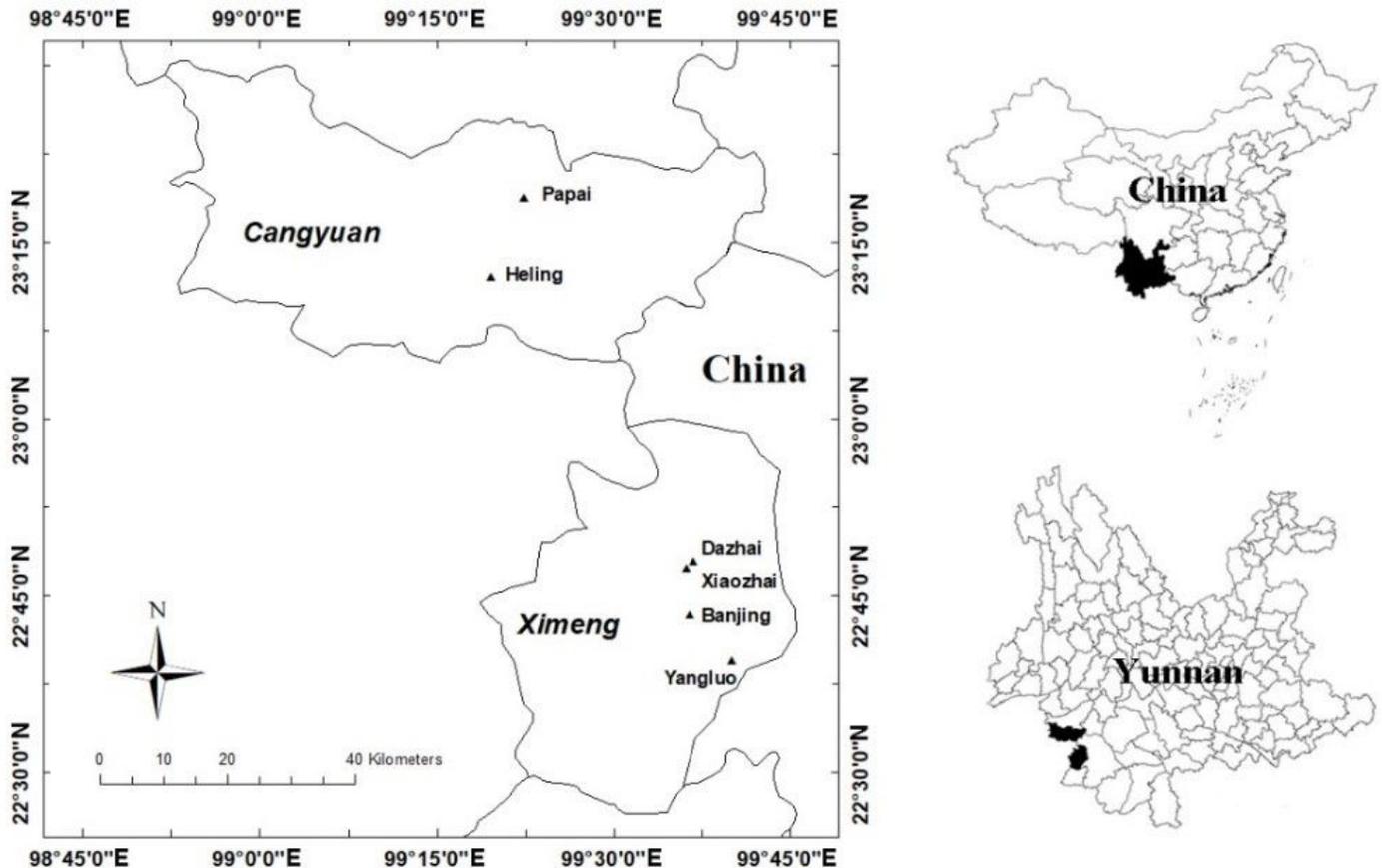


Figure 1

Geographic location of the study villages in Wa areas in China Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

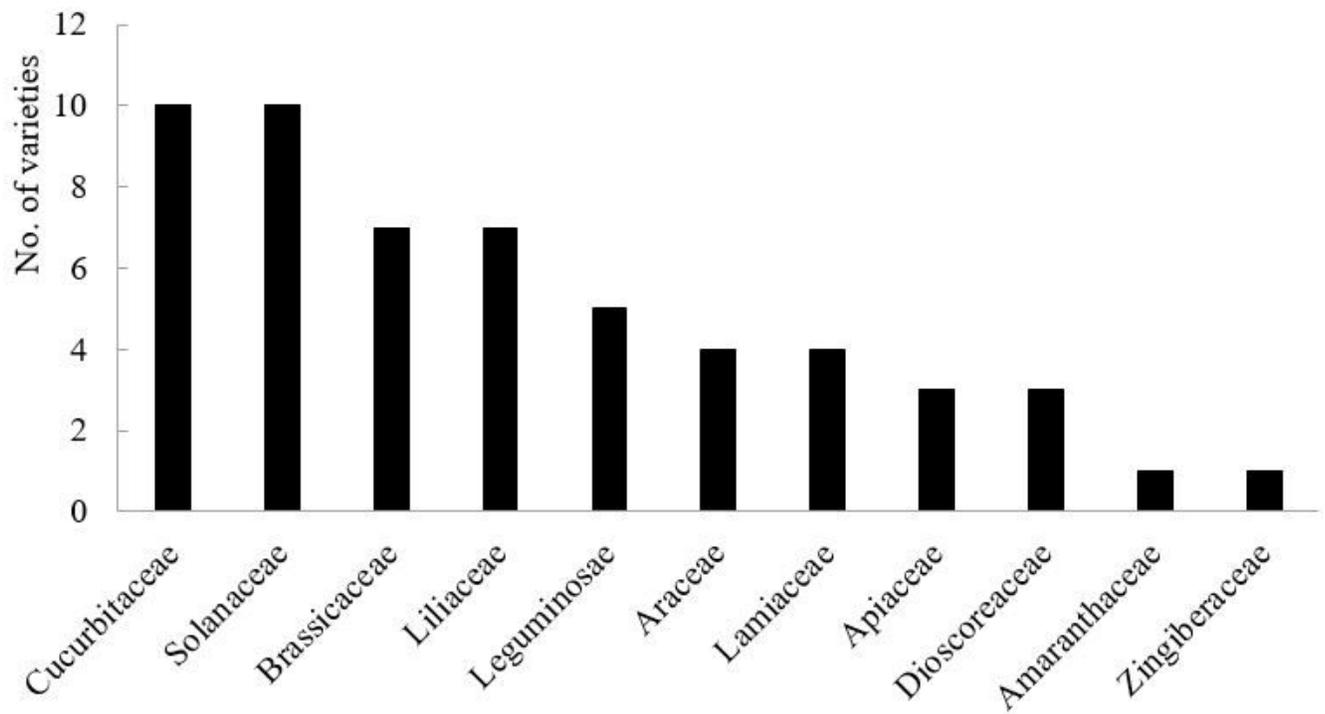


Figure 2

The taxonomic families with traditional vegetable varieties recorded in the home gardens

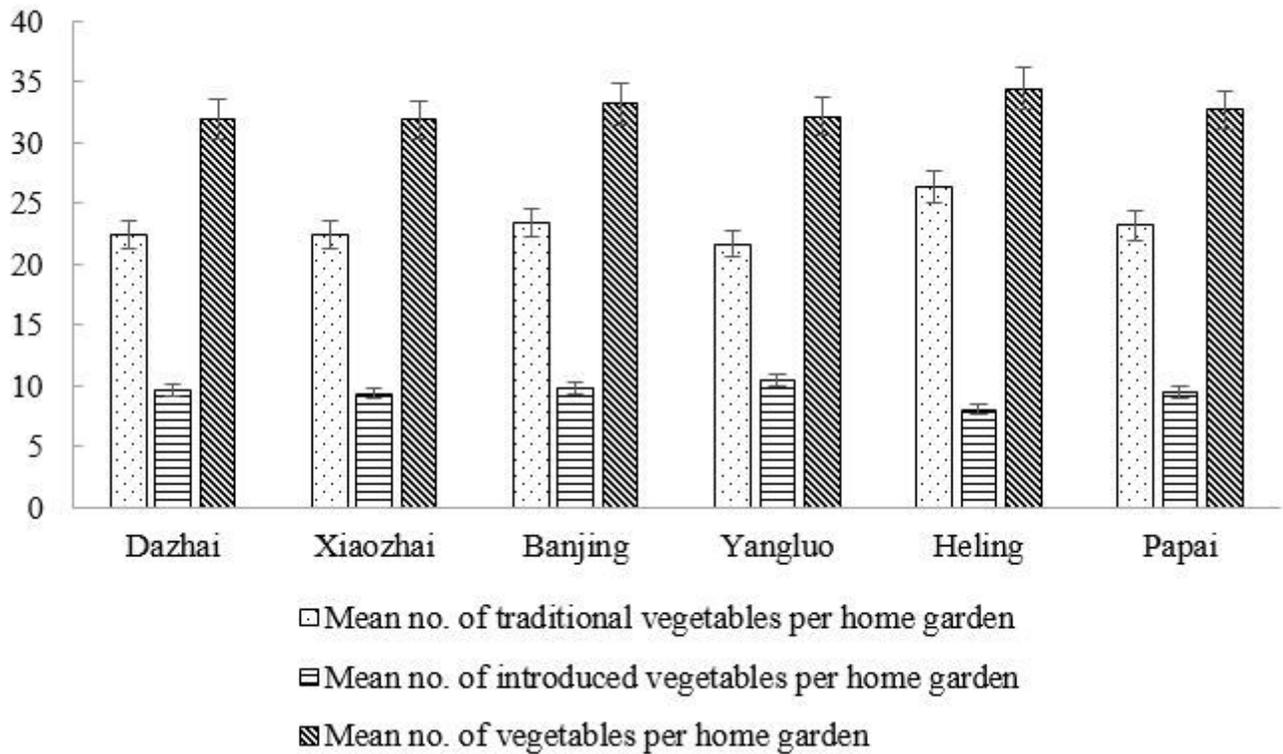


Figure 3

Portrait of vegetable diversity in six Wa villages

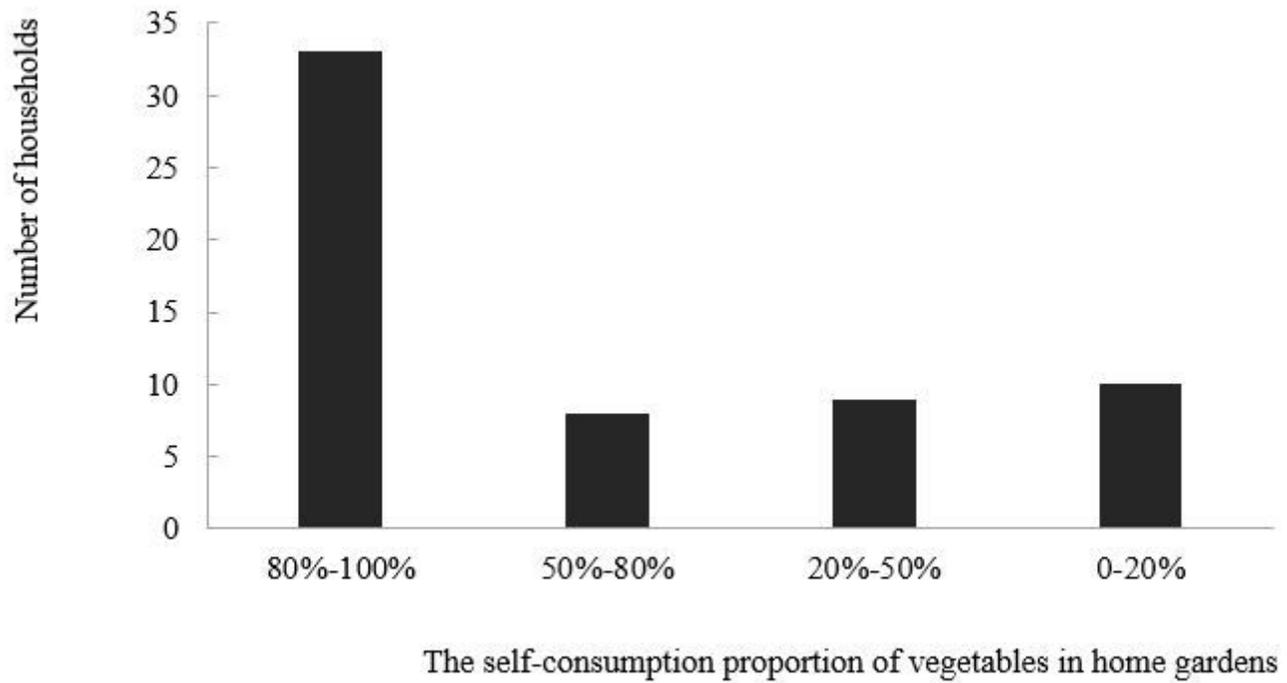


Figure 4

The proportion of total vegetables consumed sourced from home gardens

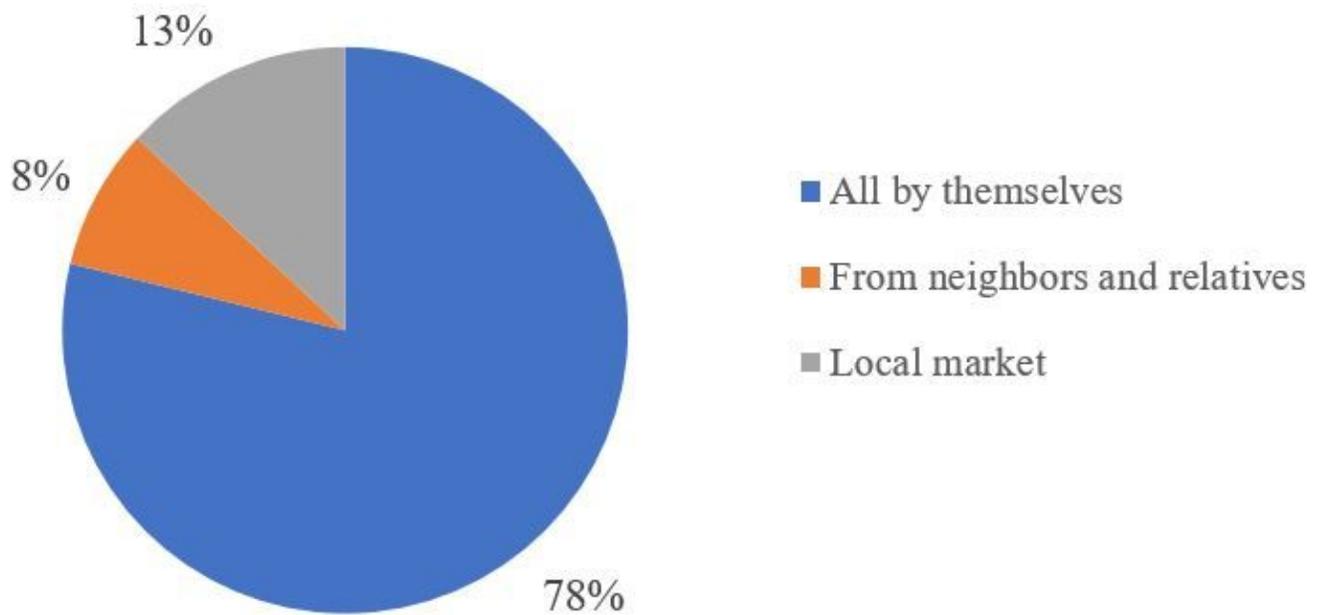


Figure 5

Proportion of households' source of traditional vegetable seed supply

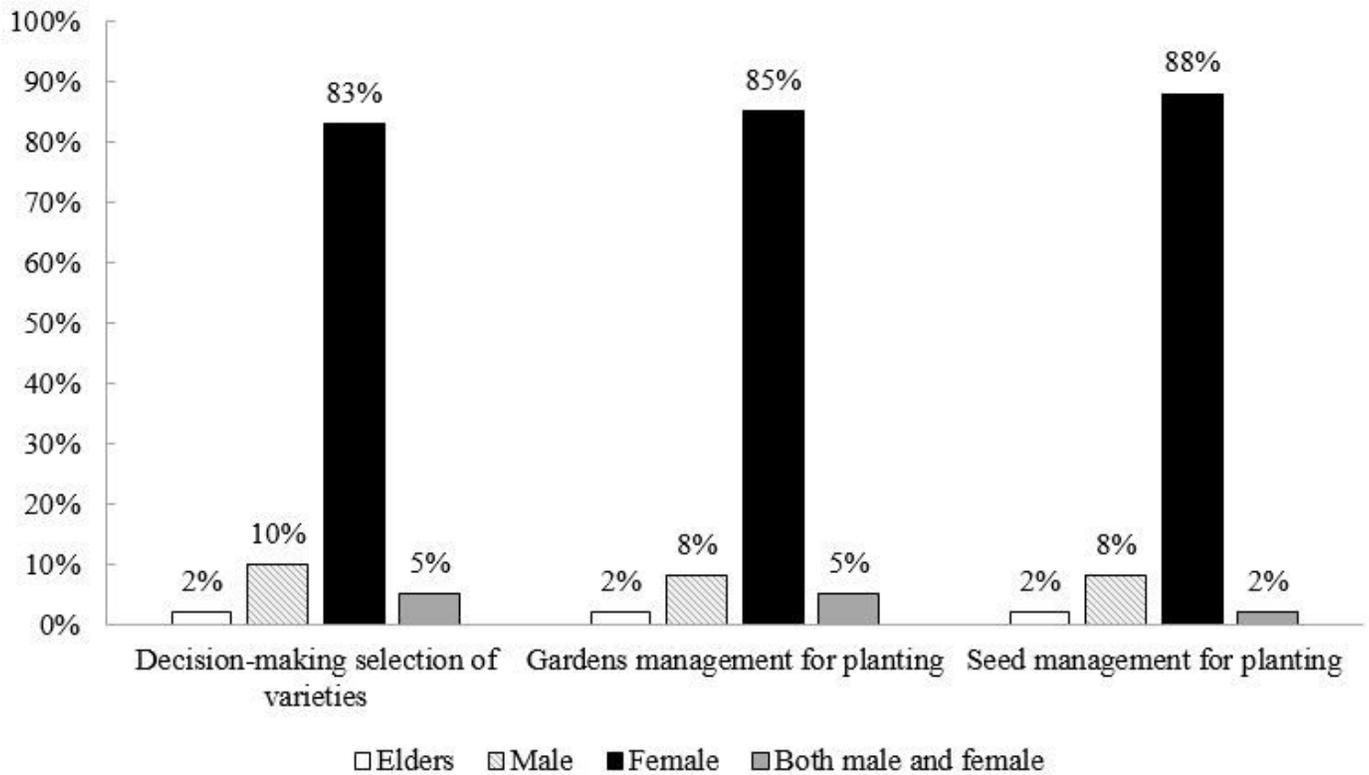


Figure 6

Responsibility for preservation and cultivation of traditional vegetables in home gardens (proportion/head of household)

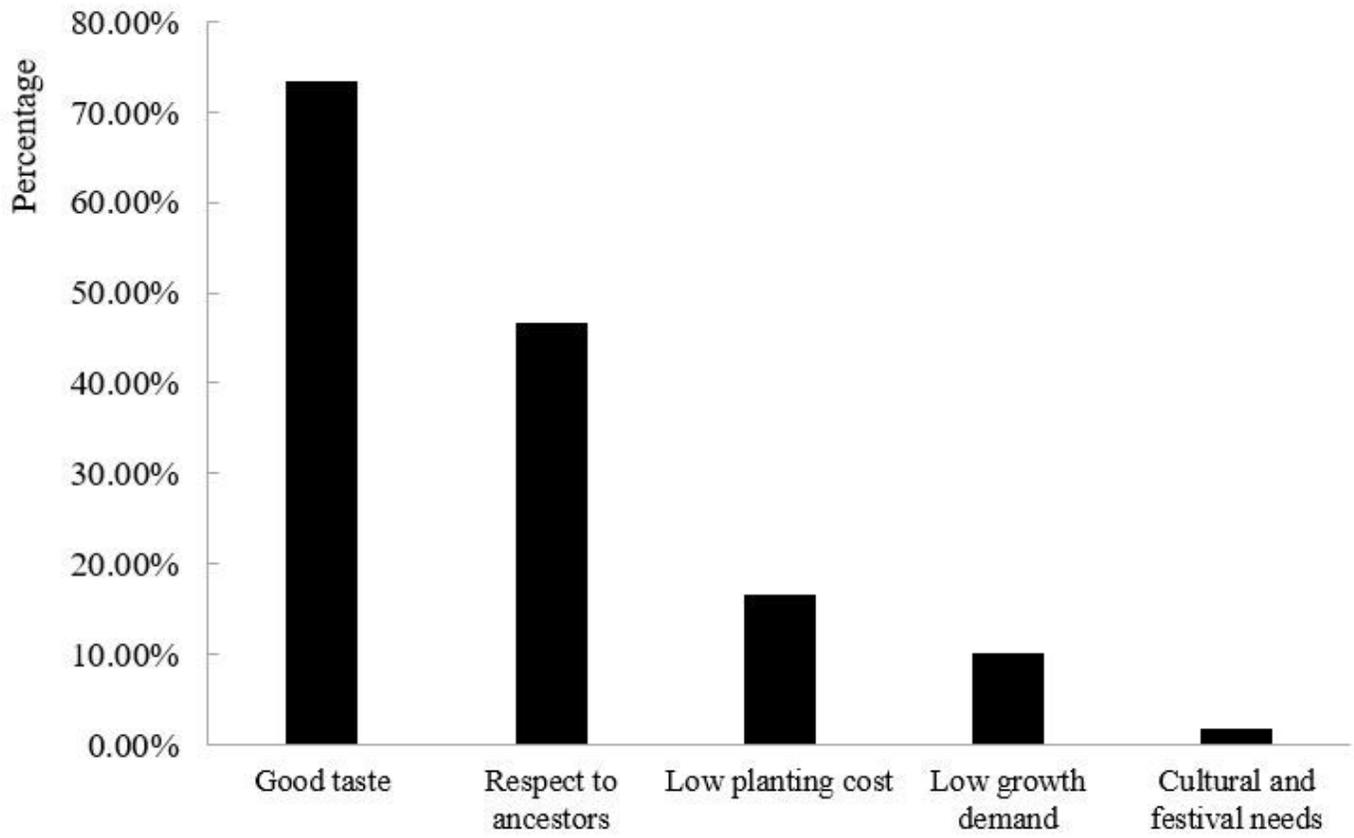


Figure 7

Factors for keeping growing traditional vegetables perceived by Wa respondents