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# Diversity of traditional vegetables and spices as local food security for the Gayo Tribe, Aceh, Indonesia

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**Abstract.** *Nelly C, Fitriyana L, Santi TD, Saudah. 2024. Diversity of traditional vegetables and spices as local food security for the Gayo Tribe, Aceh, Indonesia. Biodiversitas 25: 4699-4711.* Food is a fundamental necessity that is essential for human sustenance. The variety of traditional vegetables and spices, harvested from forests, fields, or home gardens, is critical to local food security. This study aimed to investigate the variety and utilization of local vegetables and spices by the Gayo community in Pining Sub-district, Gayo Lues District, Aceh, Indonesia and their contribution to sustainable food security. A field survey and semi-structured interviews five villages identified 75 taxa of vegetables and spices from 36 families with Zingiberaceae being the most dominant. The findings show women, who made up 68.0% of respondents, are key knowledge holders, passing down traditional plant knowledge through daily practices. Species such as *Cocos nucifera* L. and *Etlingera elatior* (Jack) R.M.Sm. showed the highest use value and frequency, underscoring their cultural and nutritional significance. However, the Gayo community faces threats, including land-use changes and the loss of traditional knowledge among the younger generation, jeopardizing plant conservation and sustainable food systems. Strategies such as sustainable agroforestry, local seed banks, and restoring traditional knowledge are essential to preserve biodiversity and ensure local food security. This research highlights the importance of preserving the diversity of traditional vegetables and spices as key elements of food security and cultural heritage.

**Keywords:** Diversity, food security, Gayo Tribe, spices, vegetables

## INTRODUCTION

Food is essential for human survival, providing energy, nutrients, and fulfilling key roles in social, cultural, and economic contexts (Shahvaly and Behrozeh 2016; Nunes et al. 2018; Reddy and van Dam 2020). Traditional vegetables and spices, sourced from forests, fields, or home gardens, are crucial for food security and nutritional diversity (Neudeck et al. 2012; Amente 2017; Aryal et al. 2018). Plant have long been used as diverse food sources, including grains, tubers, fruits, vegetables, and spices, all contributing to varied dietary patterns (Saudah et al. 2019; Zaki et al. 2019; Saudah et al. 2021a; Elfrida et al. 2021; Ivanova et al. 2021; Navia et al. 2022; Suwardi et al. 2021; Nursamsu et al. 2024). Tuber crops like cassava (*Manihot esculenta* Crantz), yams (*Dioscorea* spp.), and sweet potatoes (*Ipomoea batatas* (L.) Lam.) serve as staple foods in many regions, while leafy vegetable and spices provide essential micronutrients and medicinal benefit (Sreekumar and Charles 2022). Fruiting crops, such as bananas (*Musa* spp.), papaya (*Carica papaya* L.), and mangoes (*Mangifera indica* L.) are essential for increasing nutritional diversity and promoting the sustainability of food system. These plants abundant biodiversity emphasizes how vital they are to promoting resilience, sustaining human nutrition, and developing sustainable farming methods (Sutrisno et al. 2020; Monalisa et al. 2024).

The Gayo people, mostly residing in the highlands (Iskandar et al. 2019; Yosantia et al. 2023), have a long history of utilizing local natural resources, which makes the region well-suited for growing diverse vegetable crops (Iskandar et al. 2017; Mulyanto et al. 2018; Rahman 2018; Iskandar et al. 2020; Iskandar et al. 2023). This strong interaction with the environment fostered unique indigenous information and wisdom, including the uses of plants as food (Agesti et al. 2023). The geographical setting and cultural evolution of the Gayo people influence their dietary patterns, cooking methods, and culinary traditions (Yaris and Ozkaya 2015; Nurainas et al. 2022).

The traditional vegetables and spices hold significant nutritional and health value in Gayo cuisine, contributing to overall community well-being. Common ingredients include cassava leaves, ferns, basil, and spices such as torch ginger, turmeric, and ginger (Wakhidah and Silalahi 2019; Saudah et al. 2021b; Saudah et al. 2022). These plants are typically easy to cultivate and grow naturally, requiring minimal chemical inputs, making them both environmentally sustainable and economically effective (Mardudi et al. 2020). The knowledge surrounding these plants is passed down through generations, preserving traditional agricultural practices (Cencen and Berk 2014; López-Patiño et al. 2022).

However, modern lifestyles and the increasing preference for convenience foods are threatening the continuity of traditional plant use (Saisor et al. 2021). This shift has led to a decline in local knowledge, particularly among younger generations, and the erosion of traditional food practices (Hidayat 2017; Sutrisno et al. 2021). Traditional cuisine, which reflects a community's identity and authenticity, is at risk of being overshadowed by globalization and urbanization (Karaca and Karacaoglu 2016).

Amidst challenges like climate change, urbanization, and globalization, preserving and sustainably managing traditional food plants has become essential for enhancing local food security (Bersamin et al. 2021). Wild species, in particular, are increasingly at risk of extinction due to deforestation and habitat loss (Singh and Yan 2021).

Understanding the diversity and role of plants as food is crucial for integrating traditional knowledge with modern scientific approaches to promote food security and sustainability. Documenting the indigenous vegetables and spices used by the Gayo community is vital for safeguarding local food security, conserving biodiversity, and offering nutritionally rich, sustainable food alternatives (Silalahi et al. 2015; Geng et al. 2016; Yuliana et al. 2021). This study aims to investigate the variety of traditional vegetables and spices utilized by the Gayo people and assess their role in supporting adaptive and sustainable local food security.

## MATERIALS AND METHODS

### Study area

This research was conducted in five villages which include Pining, Pintu Rime, Pertik, Uring, and Pepelah, within Pining Subdistrict, Gayo Lues District, Aceh, Indonesia (Figure 1). These villages are geographically located between 3°47'30" - 3°58'12" North Latitude and 97°16'00" - 97°28'45" East Longitude, with altitudinal variations ranging from 500 to 1,600 meters above sea level and a slope ranging from 5 to 25 degrees. This topographical condition encompasses mountainous and valley areas, giving Pining Subdistrict its unique natural characteristics.

Covering an area of 333.01 km², this subdistrict experiences a dry to wet tropical climate, with an average annual rainfall ranging from 1500 to 3000 mm and an average temperature of 18 to 28°C. These conditions create an ideal environment for supporting a diverse ecosystem and agricultural activities. The population of Pining Subdistrict is estimated at 5,114 individuals, consisting of 2,633 males and 2,481 females (Central Bureau of Statistics of Pining Subdistrict 2024). Most of the population works as farmers, primarily cultivating coffee, vegetables, and secondary crops. The uniqueness of this study area lies in its intriguing geographical position, nestled within a vast mountainous region, resulting in a rich biodiversity of flora and fauna (Nursamsu et al. 2024).

### Data collection

Information regarding the diversity of vegetable and spice plants and their utilization by the community was obtained using the purposive snowball sampling method (Martin 1995; Albuquerque et al. 2014) and semi-structured interviews with respondents (Bernard 2017). The selection of informants aimed to ensure the acquisition of comprehensive and reliable data that would benefit researchers and ecosystem observers, and to safeguard against potential misuse of information in the future (Bender et al. 2014; Espinoza-Pérez et al. 2021). Respondents consisted predominantly of the Gayo ethnic community, aged between 15 and over 65 years old (Table 1).

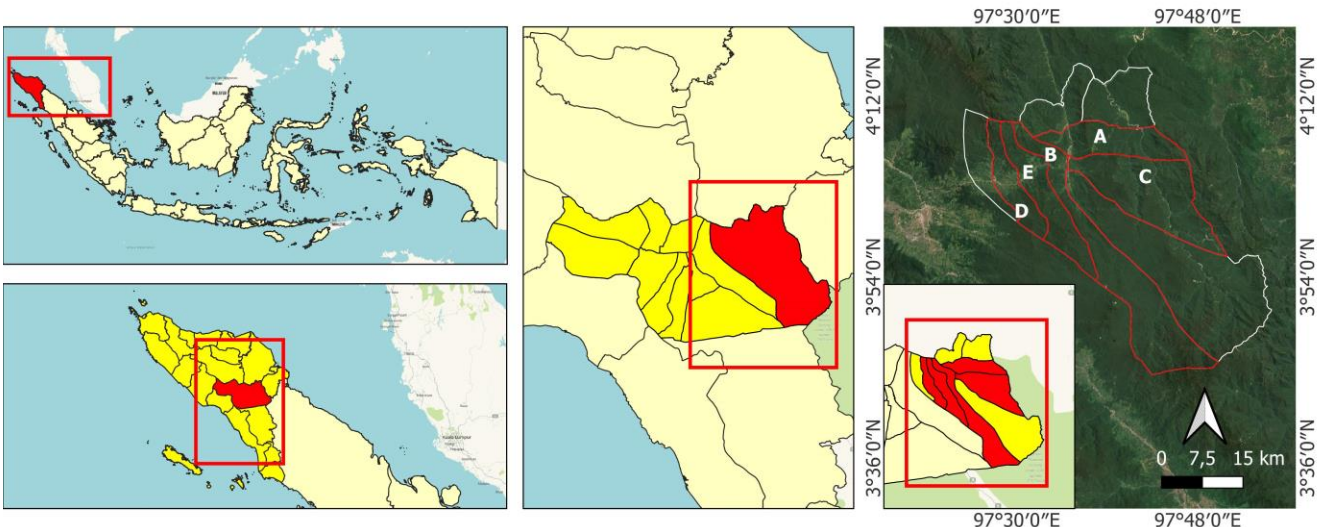


**Figure 1.** Map of Pining Subdistrict, Gayo Lues District, Aceh, Indonesia as a research area. A. Pining; B. Pintu Rime; C. Pertik; D. Uring; and E. Pepelah

**Table 1.** Demographic Structure of Respondents in Pining Subdistrict, Gayo Lues Regency, Aceh, Indonesia

| Parameter | Specification | Frequency | Percentage |
|---|---|---|---|
| Gender | Male | 32 | 32 |
| | Female | 68 | 68 |
| Age (year) | 15-25 | 9 | 9 |
| | 26-35 | 15 | 15 |
| | 36-45 | 20 | 20 |
| | 46-55 | 19 | 19 |
| | 56-65 | 20 | 20 |
| | >65 | 17 | 17 |
| Education | No Schooling | 13 | 13 |
| | Elementary School | 21 | 21 |
| | Junior High School | 34 | 34 |
| | Senior High School | 24 | 24 |
| | University | 8 | 8 |

A significant proportion of the respondents were women, as they are generally responsible for preparing for their families, providing valuable insight into the use of local plant resources. All interviews were conducted in the respondent's native language (mostly in the Gayo language) with the assistance of native interpreters, and the data were later translated into Indonesian then into English. The semi-structured interviews were guided by a questionnaire that explored various aspects of plant uses, including plant types, local names, plant parts used, processing methods, and their application as vegetables or spices in traditional Gayo cuisine, aiming to collect in-depth information regarding the utilization of local plants by the community.

In these interviews, respondents were asked to explain the types of plants and their local names, reflecting the uniqueness and local wisdom of the area. Respondents were also asked to describe the plant species, their local names, the parts used (e.g., leaves, fruits, roots, or seeds), and the processing technique. The questionnaire also addressed the frequency of use, plant sources, and potential challenges associated with their utilization, such as the availability or complexity of processing methods. Thus, these interviews not only explored technical information about the plants but also revealed their important role in the social and cultural lives of the community, which could serve as a foundation for further research or the management of local resources (Yineger et al. 2007; Heinrich et al. 2009; Lulekal et al. 2014). Some of plant identification was conducted directly in the field based on the information from people and the plant samples are also made into a herbarium. All plants were meticulously documented through photographic evidence and subsequently cross-referenced with the Plants of the World Online database (https://powo.science.kew.org/) for accurate taxonomic nomenclature.

**Data analysis**

This study employed both qualitative and quantitative descriptive analysis techniques using a survey method, where data were collected directly in the field under natural conditions. The qualitative analysis was conducted by categorizing interview data based on plant types, plant parts used, and their application in daily life, with the findings visually presented in the form of graphs and well-designed chord diagrams. Quantitative analysis involved calculating key indices such as the Use Value (UV) to assess the significance and utility of plants in the given area, Relative Frequency of Citation (RFC) to identify the most popular plants, and Index Cultural Significance (ICS) to evaluate the cultural importance of plants and Cultural Food Significance Index (CFSI) to measure the role and importance of vegetable and spice plants within the cultural context of the community. These indices also support efforts to conserve and sustain both cultural and ecological resources.

*Use Value (UV)*

Use value is a quantitative index used to evaluate the relative usefulness of a plant in the research area and aims to identify which plants have the greatest benefits in the community. The use value is calculated with a formula:

$$UV = U/N$$

Where:
U : number of reports mentioning the use of that species
N : number of informants

A higher UV value indicates that the plant species is predominantly used in daily life (Tardio and Pardo-de-Santayana 2008).

*Relative Frequency of Citation* (RFC)

Relative frequency of citation (RFC) was developed by Tardio and Pardo-de-Santayana (2008), which shows the local importance of each species where the higher the RFC value, the more popular a plant is, which results from the equation:

$$RFC = FC/N$$

Where:
FC : number of informants who mentioned the species
N : number of informants

This formula helps researchers determine how frequently a species is known or used by the community, providing insights into its cultural significance, medical importance, or ecological value. A higher RFC value indicates that the species is well-known or frequently used by informants, which may reflect its importance in local traditions or practices. This measurement is particularly useful for identifying key species within traditional knowledge systems and for prioritizing conservation efforts.

*Index Cultural Significance (ICS)*

The Cultural Significance Index (CSI) refers to a number of studies that assess the significance of a species in a cultural context. This method is frequently used in ethnobotanical research to assess how widely a plant is utilized, its intensity of usage, its practical uses, and its significance in local culture. Turner's (1988) formula is as follows:

$$ICS = \Sigma (Q \times I \times U \times C)$$

Where:

Q : number of informants or records reporting the usage of the species

I : intensity of use of the species

U : represents the plant's utility in everyday life, whether as food, medicine, or other materials;

C : reflects the plant's cultural significance.

The Index of Cultural Significance (ICS) is used to evaluate the relevance of each plant species to the community, taking into account quality, intensity, and originality of use.

*Cultural Food Significance Index (CFSI)*

Food Cultural Significance Index is intended to assess the cultural significance of food plants (Pieroni 2001). The formula for its computation is:

$$CFSI = QI \times AI \times FUI \times PUI \times MFFI \times TSAI \times FMRI \times 10^{-2}$$ (Pieroni 2001).

Where:

QI : citation frequency

AI : availability

FUI : frequency of use

PUI : plant component utilized

MFFI : multifunctional food usage

TSAI : taste appreciation score

FMRI : food-medicinal function

This score assesses the cultural significance of food plants, notably in terms of their traditional value and use as a source of nourishment or medicine.

## RESULTS AND DISCUSSION

### Socio-demographic characteristics

During the study, data were collected from 100 respondents across five villages. The respondents consisted of 32 males (32%) and 68 females (68%) (Figure 2), with ages ranging from 15 to over 65 (Figure 3). The majority of the respondents had a basic level of education (29%), with the distribution of educational attainment being as follows: No Schooling (13%), Elementary School (21%), Junior High School (34%), Senior High School (24%), and University (9%), respectively (Table 1).

The level of knowledge among respondents regarding the use of plants is dominated by women. This is because women play a crucial role in enhancing and maintaining the food supply and nutritional status of their family members through food production and processing (Ghosh et al. 2021). The role of women in maintaining family food security is closely linked to three pillars of activity: (i) food production; (ii) economic accessibility to food; and (iii) nutritional resilience. Women not only process ingredients into food but also participate in agricultural production to ensure economic access to food (Antriyandarti et al. 2024). Women have the instinct and caution to maintain food security to ensure sufficiency in facing food shortages (Chanana-Nag and Aggarwal 2020).

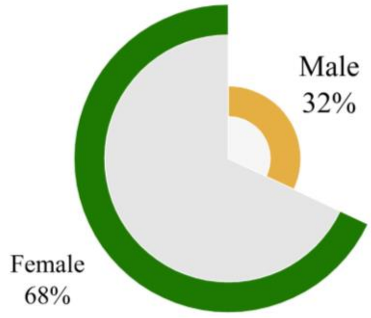


**Figure 2.** Respondent's knowledge (in percentage) on the use of vegetable and spices

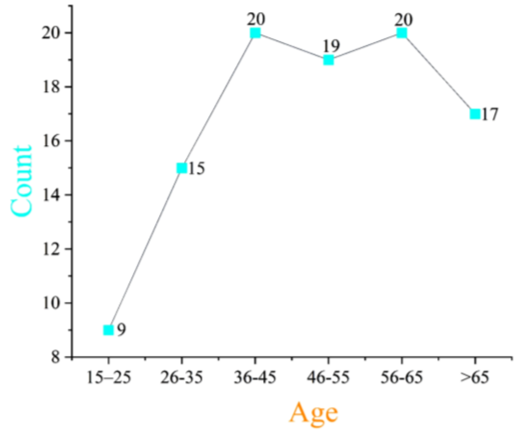


**Figure 3.** Respondent's age range

Studies show that women are at the center of the food system, participating in various stages from production to preparation and consumption of food. Knowledge of the use of plants as vegetables and spices is dominated by respondents aged 36-45 and 56-65 years, while in the youth category, the level of knowledge is low (Figure 3). The low level of knowledge among teenagers is caused by poor food choices lack in nutrition and reliance on fast food (Ensaff et al. 2015). Fast food has become the favorite food of teenagers. A limited menu offers with standard options that are prepared quickly and intended for immediate consumption. Other factors that significantly influence the consumption of fast food include brand reputation, promotional offers, and varied flavors (Oliveira and Raposo 2024). In addition, higher education has also influenced the respondents' level of knowledge about plants as food sources. The process of transformation and the effects of modernization and the habit of spending long periods away from home have significantly influenced eating patterns (Sprake et al. 2018; Alhashemi et al. 2022).

### Types of vegetables and spices

A total of 75 taxa of vegetables and spices, representing of 36 families, were documented as being used by the Gayo community in Pining Subdistrict, which play a significant role in traditional Gayo cuisine (Table 2, Figure 4). The most commonly used family was Zingiberaceae, encompassing 9 taxa out of the total 75 taxa recorded in the study area. Notably, the diversity of species observed in this study is comparatively higher than that reported in previous research by Ramaidani et al. (2022), who documented 52 different taxa from 46 genera and 31 families used by the Gayo ethnic community in their traditional cuisines. When compared to other ethnic groups in Indonesia, the diversity of vegetable and spice taxa recorded in the current study reflects a rich botanical heritage. For example, research conducted by Syamsuardi et al. (2022) showed that the Aneuk Jamee ethnic group in Sumatra (South Aceh) utilized more than 52 taxa in their traditional dishes. Similarly, the Dayak community in Kalimantan incorporates 39 taxa into their diet (Julung et al. 2021), while the Batak Karo ethnic group in North Sumatra employs approximately 85 taxa (Silalahi and Nisyawati 2018).

Additionally, the Malay ethnic group in Riau utilizes around 76 taxa (Susandarini et al. 2021), and the Sundanese people in West Java use around 65 taxa (Iskandar et al. 2023). This data indicates that the current research area is rich in biodiversity, particularly in the abundance of vegetable and spice plants. Furthermore, this high level of diversity helps preserve valuable and diverse traditional knowledge. Additionally, the substantial number of species documented in this study highlights the role of the region's vegetation as a reservoir for a wide variety of vegetable and spice taxa (Zemede et al. 2024).

**The importance value of plants**

The Use Value (UV) of vegetable and spice plants in Pining Subdistrict was calculated to assess the significance of the plants based on their utilization frequency. The UV scores in the research area ranged from 0.52 to 0.98. The top 10 plants with the highest UV included *Cocos nucifera* L. (0.98), followed by *Etlingera elatior* (Jack) R.M.Sm. (0.91), *Kaempferia galanga* L. (0.87), *Carica papaya* L. (0.84), *Phaseolus vulgaris* L. (0.84), *Dendrocalamus asper* (Schult.f.) Backer (0.84), *Zingiber officinale* Roscoe (0.84), *Passiflora edulis* Sims (0.83), *Archidendron pauciflorum* (Benth.) I.C.Nielsen (0.83), and *Myristica fragrans* Houtt. (0.82) (Figure 5).

The Relative Frequency of Citation (RFC) was used to measure the popularity of certain vegetable and spice plants based on the frequency of mentions by respondents. Higher RFC values indicate that the plant is more widely known and utilized within the community. The highest RFC value was recorded for *C. nucifera* (0.99), followed by *E. elatior* (0.98), *M. esculenta* (0.97), *S. stramoniifolium* (0.96), *C. moschata* (0.95), *O. basilicum* (0.94), *A. galanga* (0.94), *Amaranthus hybridus* (0.94), *S. brachycladum* (0.94), and *D. esculentum* (0.93). These values reflect the degree of agreement among informants regarding the usefulness of these plants in traditional medicine, underscoring their importance within the community (Figure 6).

Other important evaluation aspects are the Cultural Significance Index (ICS) and the Cultural Food Significance Index (CFSI). ICS value determines the importance of each plant species to the community, considering aspects such as quality, intensity, and uniqueness of use, whereas CFSI assesses the cultural significance of food plants, particularly in terms of their traditional value and their use as a source of nutrition or medicine. The ICS is considered crucial as it maintains the relationship between the community and the environment, supporting conservation and sustainability efforts both culturally and ecologically. It identifies plants with high cultural value within the local communities, particularly regarding their use in food, medicine, and traditions. This index is instrumental in prioritizing economically important plant, contributing to biodiversity conservation and preserving traditional knowledge, which is at risk of being lost modernization.

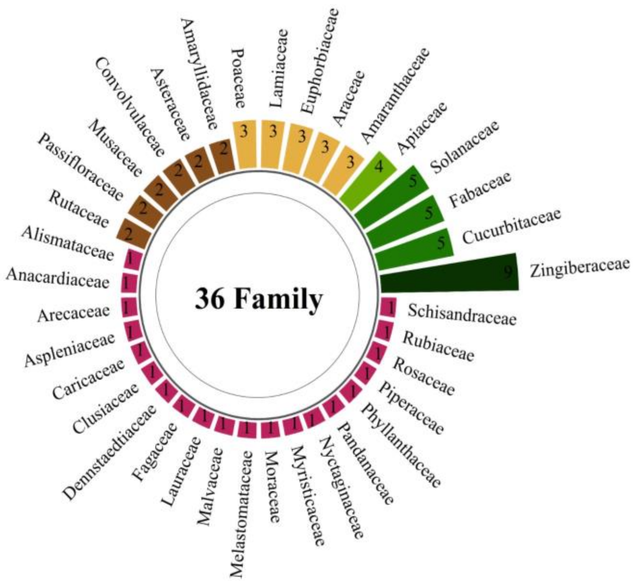


**Figure 4.** Plant family used as food and spices

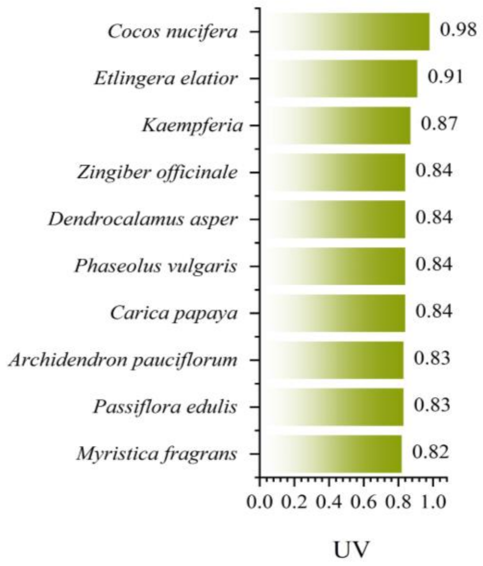


**Figure 5.** The Use Value (UV) of vegetable and spice

**Table 2.** Plant species of Vegetables and Spices in Pining Subdistrict, Gayo Lues Regency, Aceh, Indonesia

| Family | Botanical name | Local name | Part used | Habitat | Growth form | Status | Utilization | Uses | UV | RFC | ICS | CFSI |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alismataceae | *Limnocharis flava* (L.) Buchenau | *Muloh* | Leaf | Rice fields | Herb | Wild | Boiled, coconut curry | Vegetable | 0.63 | 0.83 | 25.8 | 0.29 |
| Amaranthaceae | *Amaranthus* hybridus L. | *Bayem* | Leaf | Garden | Herb | Cultivation | Boiled, coconut curry | Vegetable | 0.77 | 0.94 | 55.4 | 0.43 |
| | *Amaranthus* tricolor L. | *Bayem ilang* | Leaf | Garden | Herb | Cultivation | Boiled, coconut curry | Vegetable | 0.68 | 0.83 | 52.4 | 0.58 |
| | *Amaranthus spinosus* L. | *Bayem kurik* | Leaf | Yard | Herb | Wild | Boiled, coconut curry | Vegetable | 0.66 | 0.57 | 3.6 | 0.01 |
| Amaryllidaceae | *Allium cepa* L. | *Bawang ilang* | Tuber | Garden | Herb | Cultivation | Yellow curry, sambal cicah matah, sour curry | Spice | 0.62 | 0.8 | 132.7 | 0.5 |
| | *Allium sativum* L. | *Bawang putih* | Tuber | Garden | Herb | Cultivation | Yellow curry, sambal cicah matah, sour curry | Spice | 0.62 | 0.88 | 127.7 | 0.92 |
| Anacardiaceae | *Mangifera foetida* Lour. | *Bebelur* | Fruit | Yard | Tree | Cultivation | Sour curry | Spice | 0.63 | 0.83 | 9 | 0.06 |
| Apiaceae | *Foeniculum vulgare* Mill. | *Adas* | Seed | Garden | Herb | Cultivation | Yellow curry | Spice | 0.65 | 0.8 | 10.6 | 0.07 |
| | *Cuminum cyminum* L. | *Jintan* | Seed | Garden | Herb | Cultivation | Yellow curry | Spice | 0.63 | 0.88 | 22.8 | 0.1 |
| | *Coriandrum sativum* L. | *Tume* | Seed | Garden | Herb | Cultivation | Yellow curry | Spice | 0.64 | 0.83 | 46.8 | 0.39 |
| | *Centella asiatica* (L.) Urb. | *Pegagan* | Leaf | House yard, riverside | Herb | Cultivation | Clear vegetable soup | Vegetable | 0.7 | 0.91 | 25.8 | 0.15 |
| Araceae | *Leucocasia gigantea* (Blume) Schott | *Lumu suket* | Fruit | Forest | Herb | Wild | Yellow curry | Vegetable | 0.56 | 0.7 | 22.8 | 0.3 |
| | *Alocasia macrorrhizos* (L.) G.Don | *Gedeng* | Tuber, stem | Garden, yard | Herb | Wild | Yellow curry | Vegetable | 0.55 | 0.51 | 74.4 | 0.5 |
| | *Colocasia esculenta* (L.) Schott | *Gedeng ilang* | Tuber, stem | Garden, yard | Herb | Cultivation | Yellow curry | Vegetable | 0.65 | 0.59 | 41.1 | 0.53 |
| Arecaceae | *Cocos nucifera* L. | *Nyior* | Fruit, palm heart | Garden | Tree | Cultivation | Yellow curry, coconut curry | Spice | 0.98 | 0.99 | 144.5 | 9.97 |
| Aspleniaceae | *Diplazium esculentum* (Retz.) Sw. | *Keloang* | Leaf, stem | Forest | Herb | Wild | Yellow curry, sautéed | Vegetable | 0.63 | 0.93 | 27.2 | 0.68 |
| Asteraceae | *Elephantopus scaber* L. | *Teuleumun* | Leaf | Yard | Shrub | Cultivation | Yellow curry | Spice | 0.79 | 0.77 | 21 | 0.09 |
| | *Crassocephalum crepidioides* (Benth.) S.Moore. | *Akong* | Leaf | Forest, garden, riverbank | Herb | Wild | Boiled | Vegetable | 0.63 | 0.78 | 6.3 | 0.02 |
| Caricaceae | *Carica papaya* L. | *Pertik* | Leaf, fruit | Garden | Herb | Cultivation | Coconut curry, boiled | Vegetable | 0.84 | 0.64 | 49.2 | 1.44 |
| Clusiaceae | *Garcinia atroviridis* Griff. Ex T.Anderson | *Asam gelugur* | Fruit | Garden | Tree | Cultivation | Yellow curry, sour curry | Spice | 0.69 | 0.55 | 29.2 | 0.19 |
| Convolvulaceae | *Ipomoea aquatica* Forssk. | *Rempon putih* | Leaf, stem | Garden, riverbank | Vine | Cultivation | Yellow curry, white curry, sautéed | Vegetable | 0.64 | 0.5 | 32.6 | 0.58 |
| | *Ipomoea aquatica* Forssk. | *Rempon ilang* | Leaf, stem | Garden, riverbank | Climbing | Wild | Yellow curry, white curry, sautéed | Vegetable | 0.57 | 0.37 | 22.4 | 0.23 |
| Cucurbitaceae | *Benincasa hispida* (Thunb.) Cogn. | *Gunur* | Fruit | Garden | Climbing | Cultivation | Boiled, coconut curry | Vegetable | 0.61 | 0.41 | 28.1 | 0.23 |
| | *Sicyos edulis* Jacq. | *Labu jipan* | Fruit | Garden | Climbing | Cultivation | Boiled, coconut curry | Vegetable | 0.58 | 0.79 | 47.1 | 0.61 |
| | *Momordica balsamina* L. | *Gemes* | Leaf | Forest | Climbing | Wild | Boiled, coconut curry | Vegetable | 0.75 | 0.43 | 9.8 | 0.08 |
| | *Cucurbita moschata* Duchesne | *Penggele* | Fruit, leaf | Garden | Climbing | Cultivation | Yellow curry, boiled | Vegetable | 0.69 | 0.95 | 98.4 | 1.04 |
| | *Cucurbita pepo* L. | *Penggele manis* | Fruit, leaf | Garden | Climbing | Cultivation | Yellow curry, boiled | Vegetable | 0.71 | 0.85 | 68.4 | 1.11 |
| Dennstaedtiaceae | *Pteridium aquilinum* (L.) Kuhn | *Keloang minyak* | Leaf, stem | Forest | Herb | Wild | Yellow curry, sautéed | Vegetable | 0.57 | 0.93 | 67.6 | 0.66 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Euphorbiaceae | *Aleurites moluccanus* (L.) Willd. | *Kemili* | Seed | Garden | Shrub | Cultivation | Yellow curry | Spice | 0.62 | 0.41 | 22.8 | 0.17 |
| | *Manihot esculenta* Crantz var. *gadung* | *Ulung gadung* | Leaf | Garden | Shrub | Cultivation | Yellow curry, pounded | Vegetable | 0.59 | 0.97 | 64.4 | 0.54 |
| | *Manihot esculenta* Crantz var. *kriting* | *Ulung gadung kriting* | Leaf | Garden | Shrub | Cultivation | Boiled, coconut curry | Vegetable | 0.69 | 0.91 | 24.8 | 0.11 |
| Fabaceae | *Vigna unguiculata* subsp. Unguiculata | *Kacang naru* | Fruit, leaf | Garden | Climbing | Cultivation | Boiled, yellow curry, coconut curry, sautéed | Vegetable | 0.59 | 0.66 | 49.2 | 0.65 |
| | *Vigna angularis* (Willd.) Ohwi & H.Ohashi | *Kacang ilang* | Fruit, leaf | Garden | Climbing | Cultivation | Curry, sautéed | Vegetable | 0.63 | 0.82 | 41.2 | 0.59 |
| | *Phaseolus vulgaris* L. | *Kacang depik* | Fruit, leaf | Garden | Climbing | Cultivation | Curry, boiled | Vegetable | 0.84 | 0.49 | 22.8 | 0.2 |
| | *Archidendron pauciflorum* (Benth.) I.C.Nielsen | *Jering* | Fruit, leaf | Forest | Tree | Cultivation | Sautéed | Vegetable | 0.83 | 0.9 | 62.4 | 0.53 |
| | *Parkia speciosa* Hassk | *Pete* | Seed | Forest | Tree | Cultivation | Sambal pete | Vegetable | 0.65 | 0.52 | 56.1 | 0.69 |
| Fagaceae | *Ficus insipida* Willd | *Gele* | Fruit | Garden | Tree | Wild | Clear vegetable soup | Vegetable | 0.63 | 0.66 | 23 | 0.22 |
| Lamiaceae | *Premna serratifolia* L. | *Tememis* | Leaf | Garden | Shrub | Wild | Boiled, coconut curry | Vegetable | 0.61 | 0.81 | 6.3 | 0.04 |
| | *Ocimum tenuiflorum* L. | *Reruku* | Leaf | Garden, yard | Bush | Wild | Yellow curry | Spice | 0.61 | 0.94 | 43.2 | 0.48 |
| | *Ocimum basilicum* L. | *Kemangi* | Leaf | Forest | Bush | Cultivation | Yellow curry | Spice | 0.61 | 0.91 | 43.2 | 0.71 |
| Lauraceae | *Cinnamomum verum* J.Presl | *Kulit manis* | Bark | Garden | Tree | Wild | Yellow curry | Spice | 0.65 | 0.92 | 33.2 | 0.14 |
| Malvaceae | *Durio zibethinus* L | *Cengkudi* | Fruit | Riverbank | Tree | Cultivation | Boiled, coconut curry | Vegetable | 0.66 | 0.68 | 23.8 | 0.14 |
| Melastomataceae | *Melastoma malabathricum* L. | *Bebiki* | Leaf | Garden | Herb | Wild | Boiled | Vegetable | 0.62 | 0.88 | 28.1 | 0.18 |
| Moraceae | *Artocarpus heterophyllus* Lam | *Majek* | Fruit | Forest | Tree | Cultivation | Yellow curry, coconut curry | Vegetable | 0.61 | 0.77 | 47.1 | 0.84 |
| Musaceae | *Musa balbisiana* Colla | *Ries* | Palm heart | Garden, yard | Herb | Wild | Coconut curry | Vegetable | 0.52 | 0.89 | 9.8 | 0.14 |
| | *Musa × paradisiaca* L. | *Pisang* | Palm heart, fruit | Garden | Herb | Wild | Coconut curry, yellow curry | Vegetable | 0.61 | 0.71 | 98.4 | 2.53 |
| Myristicaceae | *Myristica fragrans* Houtt. | *Pala* | Fruit | Yard | Tree | Cultivation | Pickles, yellow curry | Spice | 0.82 | 0.9 | 26.4 | 0.23 |
| Nyctaginaceae | *Boerhavia diffusa* L. | *Rukut* | Leaf | Forest | Herb | Wild | Boiled | Vegetable | 0.67 | 0.69 | 21.2 | 0.15 |
| Pandanaceae | *Pandanus amaryllifolius* Roxb. ex Lindl. | *Pandan* | Leaf | Riverside | Herb | Cultivation | Coconut curry | Spice | 0.61 | 0.45 | 25.2 | 0.31 |
| Passifloraceae | *Passiflora edulis* Sims | *Cemenis* | Leaf | Forest | Shrub | Wild | Boiled, coconut curry | Vegetable | 0.83 | 0.91 | 1.2 | 0 |
| | *Passiflora foetida* L. | *Gamut* | Leaf | Garden | Climbing | Wild | Coconut curry | Vegetable | 0.71 | 0.8 | 24.6 | 0.1 |
| Phyllanthaceae | *Breynia androgyna* (L.) Chakrab. & N.P.Balakr. | *Nenasi* | Leaf | Garden | Shrub | Wild | Yellow curry | Vegetable | 0.64 | 0.57 | 12.8 | 0.01 |
| Piperaceae | *Piper nigrum* L. | *Leuda Pedeh* | Fruit | Forest, riverside | Herb | Cultivation | Yellow curry | Spice | 0.62 | 0.41 | 15.2 | 0.02 |
| Poaceae | *Schizostachyum brachycladum* (Kurz ex Munro) Kurz | *Tuwis* | Stem | Forest, riverside | Grass | Wild | Yellow curry | Vegetable | 0.63 | 0.94 | 37.8 | 0.95 |
| | *Dendrocalamus asper* (Schult. & Schult.f.) Backer | *Tuwis otong* | Stem | Garden | Grass | Wild | Yellow curry | Vegetable | 0.84 | 0.62 | 24.4 | 0.16 |
| | *Cymbopogon citratus* (DC.) Stapf | *Sere* | Stem | River | Herb | Cultivation | Yellow curry, sambal cicah matah, sour curry | Spice | 0.7 | 0.44 | 64.8 | 0.28 |
| Rosaceae | *Rubus moluccanus* Poir | *Cengkenir* | Fruit | River | Herb | Wild | Clear vegetable soup | Vegetable | 0.65 | 0.92 | 23.2 | 0.07 |
| Rubiaceae | *Paederia foetida* L. | *Kentutan* | Leaf | Garden, yard | Climbing | Wild | Clear vegetable soup | Vegetable | 0.63 | 0.63 | 9.8 | 0.02 |
| Rutaceae | *Bergera koenigii* L. | *Temuru* | Leaf | Garden, yard | Shrub | Wild | Curry | Spice | 0.61 | 0.68 | 37.2 | 0.4 |
| | *Citrus hystrix* DC. | *Mungkur* | Leaf | Garden | Shrub | Cultivation | Yellow curry, sambal | Spice | 0.62 | 0.81 | 39.2 | 0.5 |
| Schisandraceae | *Illicium verum* Hook.f. | *Bunge lawang* | Fruit | Garden, forest | Tree | Cultivation | Yellow curry | Spice | 0.61 | 0.63 | 25.8 | 0.12 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Solanaceae | *Solanum stramoniifolium* var. Stramoniifolium | *Ungki* | Fruit | Garden | Shrub | Wild | Sautéed, boiled, curry | Vegetable | 0.66 | 0.96 | 35.2 | 0.58 |
| | *Capsicum annuum* L. | *Lempusai ilang* | Fruit | Garden | Shrub | Cultivation | Yellow curry, sambal cicah matah, sour curry | Spice | 0.67 | 0.77 | 73.6 | 0.99 |
| | *Capsicum frutescens* L. | *Lempusai rawit* | Fruit | Garden | Shrub | Cultivation | Yellow curry, sambal cicah matah, sour curry | Spice | 0.63 | 0.87 | 79.8 | 1.22 |
| | *Solanum lycopersicum* L. | *Tomat* | Fruit | Garden | Herb | Cultivation | Sambal cicah matah, sour curry | Vegetable | 0.61 | 0.68 | 73.8 | 1.73 |
| | *Solanum melongena* L. | *Terong* | Fruit | Forest | Shrub | Cultivation | Sautéed, boiled, yellow curry | Vegetable | 0.55 | 0.89 | 64.6 | 1.55 |
| Zingiberaceae | *Etlingera elatior* (Jack) R.M.Sm. | *Cekala* | Flower, fruit | Forest | Herb | Wild | Sambal cicah matah | Vegetable, Spice | 0.91 | 0.98 | 71.4 | 3.56 |
| | *Kaempferia* sp. | *Tengango* | Rhizome, leaf | Garden | Herb | Wild | Coconut curry, yellow curry, sambal cicah matah, sour curry | Vegetable, Spice | 0.87 | 0.56 | 37.6 | 1.28 |
| | *Curcuma longa* L. | *Kuning* | Rhizome, leaf | Garden | Herb | Cultivation | Yellow curry, coconut curry, sour curry | Spice | 0.63 | 0.89 | 65.7 | 3.93 |
| | *Zingiber officinale* Roscoe | *Baing* | Rhizome | Garden | Herb | Cultivation | Yellow curry | Spice | 0.84 | 0.58 | 52.8 | 1.07 |
| | *Alpinia galanga* (L.) Willd. | *Lengkues* | Rhizome | Forest | Herb | Cultivation | Yellow curry, sour curry | Spice | 0.7 | 0.94 | 59.1 | 1.16 |
| | *Alpinia purpurata* (Vieill.) K.Schum. | *Terpuk* | Palm heart | Garden | Herb | Wild | Yellow curry, white curry | Vegetable | 0.65 | 0.72 | 43.4 | 0.61 |
| | *Kaempferia galanga* L. | *Cekur* | Rhizome | Garden | Herb | Cultivation | Yellow curry | Spice | 0.63 | 0.5 | 37.2 | 0.18 |
| | *Elettaria cardamomum* (L.) Maton | *Kapule* | Rhizome | Forest | Herb | Cultivation | Yellow curry | Spice | 0.61 | 0.64 | 40.2 | 0.25 |
| | *Zingiber zerumbet* (L.) Roscoe ex sm. | *Lempuyang* | Rhizome | Hutan | Herb | Wild | Yellow curry, sour curry | Vegetable | 0.59 | 0.52 | 49.2 | 0.4 |

Similarly, the CFSI assesses the role and value of food plants within the cultural context of a community, measuring their importance in traditional diets and as a source of nutrition and medicinal value. The CFSI supports biodiversity conservation and protects traditional knowledge related to local food, thereby promoting food security and cultural identity. The top 10 plants with the highest ICS values were *Cocos nucifera* (144.5), followed by *A. cepa* (132.7), *A. sativum* (127.7), *C. moschata* (98.4), *M.* × *paradisiaca* (98.4), *C. frutescens* (79.8), *A. macrorrhizos* (74.4), *S. lycopersicum* (73.8), *C. annuum* (73.6), and *E. elatior* (71.4) (Figure 7). Meanwhile, the top 10 plants with the highest CFSI values were *C. nucifera* (9.96), followed by *C. longa* (3.93), *E. elatior* (3.56), *M.*× *paradisiaca* (2.53), *Solanum lycopersicum* (1.72), *S. melongena* (1.54), *C. papaya* (1.44), *K. galanga* (1.28), *Capsicum frutescens* (1.21), and *A. galanga* (1.16) (Figure 8).

**Utilization of vegetables and spices**

The utilization patterns of vegetable and spice plants were further analyzed in terms of the plant parts used. For vegetables and leaves were the most commonly used part with a total of 25 taxa, followed by fruits (14 taxa), stems (7 taxa), flowers (1 taxon), and palm hearts (1 taxon). Meanwhile, for spices, fruits, leaves, and rhizomes were each utilized by 7 taxa, while stems (2 taxa), seeds (5 taxa), flowers (1 taxon), bark (1 taxon), tubers (2 taxa), and palm hearts (2 taxa) were also employed. This differentiation between the plant parts used for vegetables and spices indicated a preference for leaves and fruits in the vegetable category, whereas rhizomes were predominant in the spices category (Figure 9). In terms of traditional dishes, yellow curry (33.8%) was the most frequently mentioned, followed by boiled (19.2%), coconut curry (16.2%), sour curry (9.2%), stir-fried (6.9%), *sambal cicah matah* (raw chili sauce) (6.2%), curry (2.3%), white curry (2.3%), *sambal pete* (chili petai sauce) (0.8%), pounded (0.8%), *kari* (curry) (0.8%), pickles (0.8%), and *sambal* (chili sauce) (0.8%) (Figure 10).

In terms of plant parts used, leaves (35%) were the most frequently used, followed by fruits (27%), stems (9%), rhizomes (7%), seeds (5%), palm hearts (4%), tubers (4%), flowers (1%), and bark (1%) (Figure 11). This data highlights that leaves were the most commonly preferred part by the community, likely due to their ease of processing compared to other plant parts (Ismail and Ahmad 2019; Nehru et al. 2024).

Leaves are often used because they are easy to obtain, simple to process, and contain beneficial bioactive compounds. In culinary applications, leaves are highly valued for their versatility, whether as a main ingredient or complementary element in dishes. Examples include boiled vegetables, stir-fries, and fresh salads. Besides imparting distinct flavor, many leaves used in cooking also offer health benefits due to their rich in nutritional profiles, such as those from papaya and spinach leaves. The use of leaves in cooking not only enhances the flavor but also enriches the nutritional content of the community's daily diets. As for their use as spices, stems and rhizomes were often preferred due to their distinctive aroma and flavor (Saudah et al. 2022). The local community's ethnobotanical knowledge is strongly influenced by the environmental conditions and the availability of plant resources in their surroundings (Beltran-Rodríguez et al. 2014).

**The role of vegetables and spices in the food security of the Gayo community**

Vegetables and spices are integral to the Gayo community's food security, serving not only as a source of nutrition but also as key components of their culinary traditions and traditional medicine (Ramaidani and Navia 2022). Local agroforestry systems, which form the backbone of the Gayo Highland's agricultural landscape, play a crucial role in sustaining this reliance on natural resources. These systems combine various vegetables, such as cassava leaves, water spinach, turmeric, and ginger, in a sustainable manner. By integrating vegetable and spices into home garden and mixed-crop systems, the community ensures as year-round supply of diverse food sources while preserving the ecological balance of their natural habitats (Fuchs et al. 2019; Mardudi et al. 2020; Chicas et al. 2023).

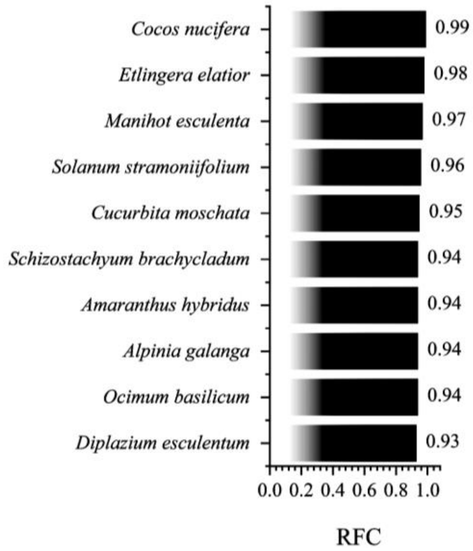


**Figure 6.** Relative Frequency of Citation (RFC)

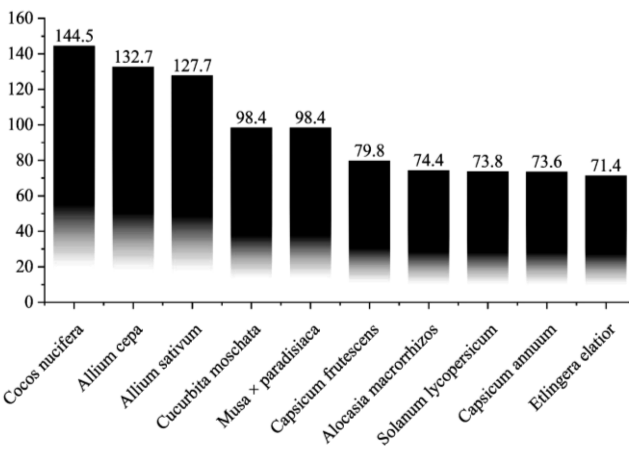


**Figure 7.** Cultural Significance Index (ICS)

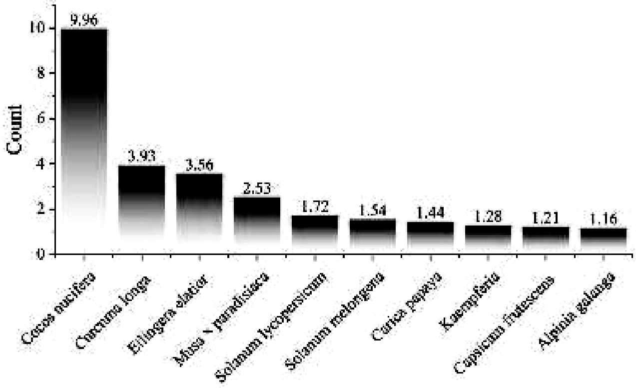


**Figure 8.** Cultural Food Significance Index (CFSI)

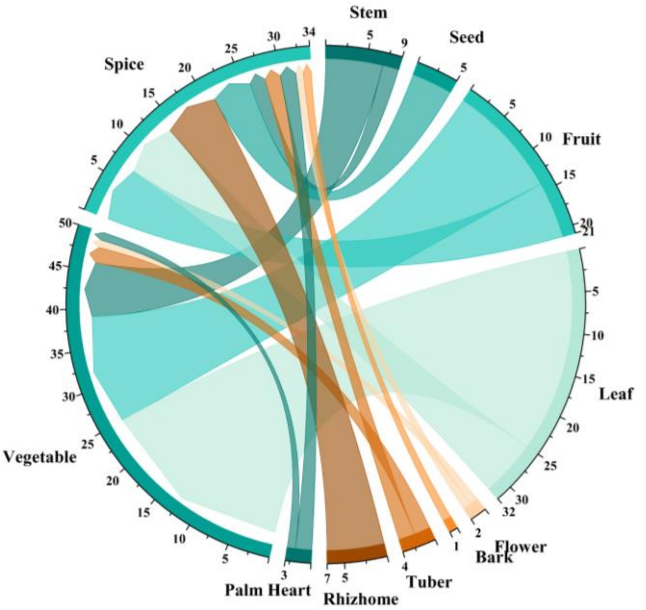


**Figure 9.** List of taxa, categories, part used of food plants used in Gayo Tribe

The diverse habitats of the Gayo Highlands, with elevations ranging from 500 to 2,000 meter above sea level (masl), create ideal conditions for cultivating a wide range of vegetable and spices. The regions's agroforestry systems reflect the community's deep understanding of local biodiversity, enabling the efficients use of land and resources to support food security. Moreover, these crops contribute to food sustainability through traditional processing and storage techniques, allowing surplus produce to be preserved for extended periods. The cultural significance of spices in traditional ceremonies also strengthens social bonds and emphasizes the importance of food as a communal resource (Britwum and Demont 2022). Additionally, the Gayo practice of sharing harvests fosters a sense of collective food security, ensuring that no household faces food shortages. Ultimately, the cultivation and use of vegetables and spices from the agroforestry systems of the Gayo Highlands not only ensure nutritional diversity and ecological sustainability but also reinforce social traditions and support long-term food independence for the Gayo people (Robinson 2024).

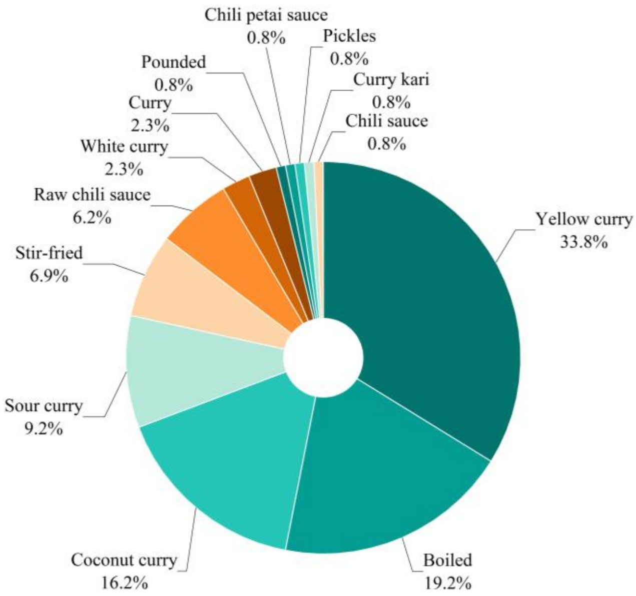


**Figure 10.** Culinary applications of plants

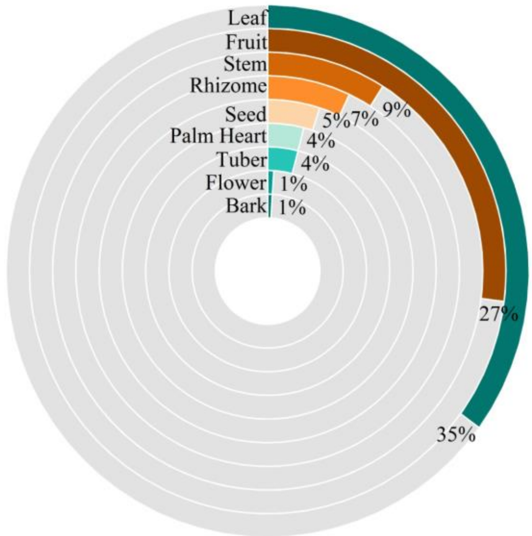


**Figure 11**. Parts of plants use as cooking ingredients

## Conservation challenges and threats to biodiversity

The local diversity of vegetable and spice utilized by the Gayo commuity faces complicated conservation problems and threats. Land-use change is one of the most significant issue, where forests and traditional agricultural land are converted into large-scale plantations or infrastructural development (Tchonkouang et al. 2024). This transformation can jeopardize the sustainability of indigenous flora and lead to the loss of natural habitats for numerous vegetable and spice species traditionaly used by the Gayo population. Furthermore, agricultural modernization, which includes the introduction of commercial crops and the use of chemical fertilizers and pesticides, poses a risk to local biodiversity (Robinson 2018). Reliance on modern crops may cause the community to abandon native plants that hold significant cultural and nutritional value. Climate change is another major factor affecting traditional agricultural practices, as fluctuations in rainfall and temperature can alter the growth of native plants that are sensitive to climatic conditions (Gomez-Zavaglia et al. 2020). Additionally, the loss of traditional knowledge among younger generations is a growing concern, as interest in modern technology and medicine may lead to the abandonment of traditional practices of using vegetables and spices (Adnan et al. 2022). If knowledge of these plants is not adequately transmitted, the loss of biodiversity and cultural legacy could accelerate (Suwardi et al. 2021; Kahrić et al. 2022). To preserve the long-term viability of native Gayo vegetables and spice diversity, conservation activities must focus on the documentation and restoration of traditional knowledge, sustainable land management, and community engagement in environmental protection. This highlights the importance of supporting even the smallest initiatives to conserve knowledge on Gayo food plant biodiversity (Ramaidani and Navia 2022).

**Recommendations for innovation in sustainable management and development**

The conservation of native vegetable and spice diversity among the Gayo community faces significant challenges arising from multiple interconnected factors (Kanter et al. 2018; Blair et al. 2024). A primary concern is land-use change, where the conversion of forests and traditional agricultural land into large-scale plantations or infrastructural development endangers the sustainability of native flora (Montanarella and Panagos 2021). This transition results in the loss of natural habitats essential for many vegetable and spice species that are vital to the traditional Gayo community. Additionally, the modernization of agriculture, including the widespread adoption of commercial crops and the use of chemical fertilizers and pesticides, has been shown to negatively impact local biodiversity (de Clercq et al. 2018). The shift towards reliance on high-yeild contemporary crops risks the abandonment of native plants with significant cultural and nutritional value. Climate change further exacerbates these challenges, as fluctuations in rainfall patterns and temperature significantly affect the growth and development of climate-sensitive native plant species. Moreover, the erosion of traditional knowledge among younger generations, driven by a preference for modern technology and medicine, poses a risk the preservation of indigenous agricultural practices. Without effective transmission of traditional knowledge, the loss of biodiversity and cultural heritage could accelerate leading to diminished ecological sustainability and the erosion of community identity and traditional practices (Robinson 2018; Robinson 2024).

Addressing these threats requires a multifaceted approach. Systematic documentation and preservation of traditional knowledge should be prioritized and integrated into education and cultural programs to unsure intergenerational transfer. Promoting sustainable land management practices that balance agricultural productivity with biodiversity conservation is essential. Community participation plays a pivotal role in foresting local ownership of conservation efforts, enhancing innovation in sustainable management, ensuring the long-term preservation of traditional agricultural practices. In terms of climatic challenges, locally tailored climate adaptation strategies, including the development of climate-resilient crop varieties the establishment of seed banks, and improved water management system, should be implemented. A comprehensive and collaborative approach is crucial to sustaining the native vegetable and spice diversity of the Gayo community and preserving their cultural and ecological heritage (Robinson 2024).

In conclusion, this research successfully documented 75 vegetable and spice taxa from 36 families with Zingiberaceae being the most dominant. This finding demonstrates the extensive ethnobotanical knowledge of the Gayo ethnic community regarding the use of vegetable and spice plants. Out of 100 respondents surveyed, the majority were women (68.0%) and aged between 15 and over 65 years. Most of the community's education level was basic education (29.0%), indicating that traditional knowledge of vegetable and spice plants is passed down informally in daily life. Important indices such as Use Value (UV) and Relative Frequency of Citation (RFC) were used to measure the significance of certain species. The significance of specific species, such as *C. nucifera* and *E. elatior*, is demonstrated by their high Use Value (UV) and Relative Frequency of Citation (RFC). These indices reveal the importance of these plants in meeting daily needs, from food to traditional medicine. The high Cultural Significance Index (ICS) and Cultural Food Significance Index (CFSI) of plants like *C. nucifera* and *C. longa* further illustrate their vital roles in sustaining cultural identity and food security. The frequent use of leaves, fruits, and stems reflects the community's comprehensive utilization of plants, enhancing both nutrition and health.. However, the sustainability of this rich biodiversity faces significant challenges. Land-use changes threaten the availability of natural habitats, while younger generations risk losing traditional knowledge due to modernization. Addressing these issues requires proactive measures, such as implementing sustainable agroforestry practices, establishing local seed banks, and revitalizing cultural education programs. By fostering an appreciation for traditional knowledge and its integration with modern conservation strategies, the Gayo community can ensure the preservation of their invaluable biodiversity and cultural heritage for future generations.

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