Bio-cultural habits of plant consumption in the food system of traditional Sasak's villages (Indonesia)

Wawan Sujarwo, Yen Yen Sally Rahayu, Kurniasih Sukenti, Nyoman Lugrayasa, Ary Prihardhyanto Keim and Vincenzo Zuccarello

Correspondence

Wawan Sujarwo[1], Yen Yen Sally Rahayu[1*], Kurniasih Sukenti[2], Nyoman Lugrayasa[3], Ary Prihardhyanto Keim[4] and Vincenzo Zuccarello[5]

[1]Research Center for Ecology and Ethnobiology, National Research and Innovation Agency (BRIN), Cibinong 16911, Bogor, Indonesia.
[2]Department of Biology, Faculty of Mathematics and Natural Sciences, Mataram University, Mataram 83115, Indonesia.
[3]Research Center for Applied Botany, BRIN, Cibinong 16911, Bogor, Indonesia.
[4]Research Center for Biosystematics and Evolution, BRIN, Cibinong 16911, Bogor, Indonesia.
[5]Department of Sciences and Biological and Environmental Technology, Salento University, Polo Ecotekne 73100, Lecce, Italy.

*Corresponding Author: yenyenrahayu@gmail.com

Ethnobotany Research and Applications 30:22 (2025) - http://dx.doi.org/10.32859/era.30.22.1-15
Manuscript received: 12/09/2024 - Revised manuscript received: 15/02/2025 - Published: 17/02/2025

Research

Abstract

Background: The Sasak people are the Indigenous population of Lombok Island. In a rural context, traditional villages (**desa adat**) represent the most conservative segment of Sasak's ethnicity, where they continue to uphold original customs and bio-culturally preserve the traditional ecological knowledge (TEK). A significant aspect of TEK relates to plant-based foods and their consumption habits. This study aimed to elucidate dietary habits associated with plant consumption by identifying several bio-cultural traits linked to specific groups of plant parts (botanicals) consumed with varying frequencies throughout the year.

Methods: Data were collected using Food Frequency Questionnaires administered to 35 women in seven Sasak traditional villages. Statistical analyses, including cluster analysis and Principal Component Analysis, were performed using Ginkgo software to identify bio-cultural traits associated with botanical consumption patterns.

Results: The study documented 77 botanicals from 68 plant species and 33 families consumed in Sasak traditional villages. Cluster analysis identified five groups of botanicals with distinct consumption patterns, ranging from seasonal to daily use. The findings revealed two plant consumption cycles in the traditional Sasak diet: a primary cycle centered around white rice as a staple and a secondary cycle that increased dietary diversity through seasonal fruits and plant-based dishes.

Conclusions: The observed patterns of plant consumption highlight their significance in sustaining traditional Sasak diets and bio-cultural practices. These patterns demonstrate how the traditional food system is shaped by the Sasak people's bio-cultural traits, emphasizing the importance of preserving their unique food systems as a bio-cultural signature of Indigenous People and traditional villages.

Keywords: Bio-cultural erosion, Indigenous Sasak people, Food-Frequency Questionnaires, Traditional Diet, Food plant, Fruit plant, Lesser Sunda Island, Stunting

Background

Indigenous Peoples are native populations that existed prior to colonization and were affected by the colonialist and imperialist forces during the Second Millennium. Today, they are often considered ethnic minorities within modern nations that emerged after the colonial period (UN 2007). These groups possess a strong cultural identity and proudly consider themselves as distinct ethnic communities, maintaining and transmitting their own traditions, beliefs, and knowledge. An important part of this knowledge, developed over millennia, involves the sustainable use of natural resources in their ancestral territories, particularly through their traditional food systems (Kuhnlein *et al*. 2009).

Traditional food systems encompass every culturally acceptable item used in the diet of indigenous populations (Kuhnlein & Receveur 1996). Culture, environment, affordability, and people's biological needs shape dietary habits that characterize local communities. Dietary choices are influenced by factors such as food availability, climate, agriculture, trade, and wildlife, as well as beliefs, preferences, and the disposable income of a population (Turner *et al*. 2013). In general, dietary habits are largely responsible for the nutritional status and health conditions of a community (Kuhnlein *et al*. 2009). Some indigenous populations have been able to manage nutritional deficiencies throughout the year by adopting flexible consumption strategies that include nutraceutical and wild foods (Turner &Turner 2007), while others have been affected by severe diseases due to their dietary habits despite living in environments with abundant food resources (Eng *et al*. 2022).

Traditional Ecological Knowledge (TEK) (Inglis 1993) plays a pivotal role in shaping nutritional habits within indigenous communities by reflecting the complex relationships between culture and nature, which are developed through environmental adaptation and cultural transmission (Alcorn 1981). TEK can be considered a specific aspect of a holistic approach based *on* bio-cultural diversity (Maffi 2001), which integrates biological and cultural diversity into a unified concept. In this context, dietary habits can be interpreted as peculiar bio-cultural traits (Sujarwo *et al*. 2019) of a traditional food system and diet.

Crops, semi-wild, and wild plants —primarily sourced from local smallholdings, home gardens, and wild—are vital resources for the nutrition, well-being and economy of isolated traditional communities (Turner *et al*. 2013). Plants and plant parts, also referred to as botanicals (Reynertson & Mahmood 2015) to describe generic materials obtained from plants, provide a major portion of the available food for native communities, significantly contributing to their nutritional needs (Engelberger *et al*. 2013). To date, local food production and supply chains have generally been developed independently from international markets (Waltz 2011) by conserving and preserving a wide range of edible plants and regional plant diversity (Johns & Sthapit 2004).

Bio-cultural habits of plant consumption are then essential in defining and describing a traditional food system by highlighting the crucial links between nature and culture (Barthel *et al*. 2013). Food-Frequency Questionnaires (FFQs) are commonly used in epidemiological studies as a cost-effective method for assessing dietary intake of a population, providing data on the consumption frequency of food items from a predetermined list (Ocké 2013). However, FFQs can suffer from imprecision and errors because they rely on memory, habits and traditions of informants to estimate typical portion sizes, which can vary greatly across different eating events (Farshchi *et al*. 2017). In ethnobotanical studies, this limitation is outweighed by the advantage of obtaining reliable information about community habits and traditions. Therefore, FFQs can be effective tools for describing traditional food systems in terms of bio-cultural traits (Sujarwo *et al*. 2019), provided that the food item list is constructed based on the community's shared knowledge. In this context, bio-cultural traits refer to sets of biological elements used similarly within a specific socio-ecological system.

Using ethnobotanical knowledge and data from FFQs, groups of plants and botanicals can be identified as bio-cultural traits related to specific dietary habits. These traits reflect different behaviors over time, influenced by the phenology and availability of plant species, as well as the traditions and customs of the community. A multivariate approach, such as the cluster analysis suggested by Sujarwo *et al*. (2019), can synthesize multiple data points into clusters (groups) of botanicals consumed at similar frequencies. This allows for the interpretation of traditional food systems in terms of the main bio-cultural habits linked to plant consumption by Indigenous Peoples. Ultimately, this approach could be valuable in advancing the Sustainable Development Goals, particularly in addressing zero hunger and promoting good health and well-being in native communities (UN 2023).

The Sasak are Austronesian people living on the island of Lombok, located east of Bali. Despite being separated from Bali by a relatively narrow strait (ranging from 16 to 40 km), the Sasak have their own unique identity and language, distinct from the Balinese. Nevertheless, linguistically, Sasak and Balinese are considered closely related, belonging to the Malayo-Chamic language group, or at a higher level, the Western Malayo-Polinesian group (Tryon 2006, Blust 2013). The Sasak is the dominant ethnic group on Lombok, comprising 93% of the population. As an indigenous group, the Sasak have been shaped by significant influences from Balinese, Javanese, Arabic and Dutch (the colonial power in the former Dutch East Indies, now Indonesia) cultures throughout the Second Millennium, yet have maintained their distinct identity up to at least the 20th century (Sujarwo 2019).

Unfortunately, only a few traditional Sasak villages continue to conserve and preserve their original culture and customs today (Sujarwo 2019, Rahayu *et al*. 2021). Most of the Sasak population faces the risk of losing their cultural identity due to cultural erosion driven by globalization (Sujarwo *et al*. 2014). Furthermore, traditional villages often experience extreme rural poverty and are heavily affected by high rates of stunting syndrome (Irawati *et al*. 2022).

Regarding their ethnic cuisine, many Sasak people have already forgotten their traditional healthy food, which have sustained their health and survival over the years (Sujarwo 2019). While the ethnobotany of cuisine from Lombok Island has been studied by Sukenti *et al*. (2016), this research encompassed the entire Sasak population across the island and did not specifically focus on the traditional villages, which are the most representative of Sasak culture. Moreover, no one has quantitatively described the frequencies of plant consumption and related habits in the traditional Sasak diet. This research aims to address this knowledge gap, emphasizing the importance of conserving and protecting ethnic dietary practices to maintain the Sasak identity and preserve the bio-cultural diversity of Indigenous Peoples.

Materials and Methods

Study area

The areas selected for this study included seven villages. These villages spread across different parts of Lombok Island, namely Sade and Ende Villages in the south; Segenter and Gumantar Beleq Villages in the northwest; Bayan Timur and Senaru Villages in the north; and Sembalun Lawang Village in the northeast (Fig. 1). Even though all these villages are inhabited by the Sasak people, each has its own unique characteristics in terms of language, customs, arts, and even the culinary traditions. The traditional nature of these villages is also evident from their building structures, which differ significantly from those of modern villages. Village life typically relies on agriculture and traditional crafts (McKinnon 1996). Most residents of these seven villages depend on the agriculture, although many have recently begun developing the tourism sector. Sade and Ende, in particular, are well-known as traditional tourist villages.

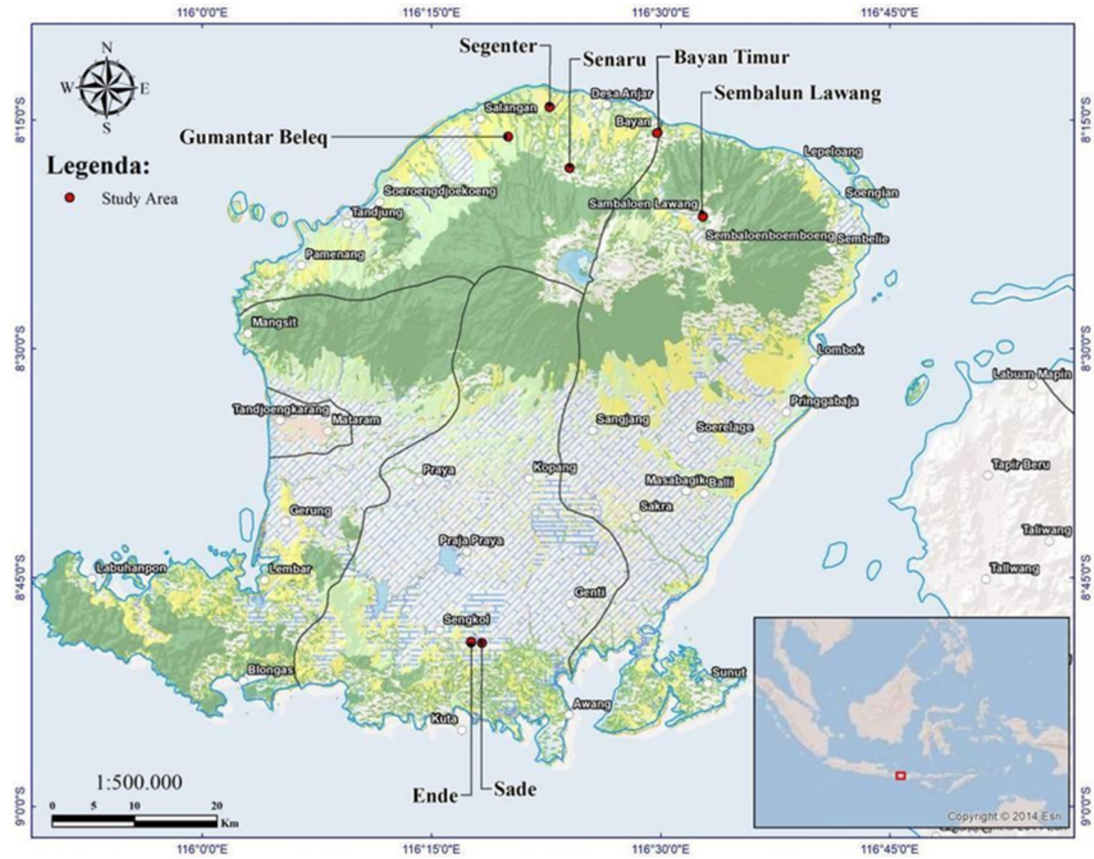

Figure 1. Map of Lombok and locations of traditional villages

The northern part of Lombok Island is mostly characterized by higher elevations than the south. This region includes the Rinjani volcanic mountain range (3726 m), making it one of the three highest peaks in Indonesia and a popular destination for trekkers and climbers. Most of Lombok's population resides in the central plains, in a corridor stretching from Mataram, the capital of West Nusa Tenggara Province (NTB), to the port of Labuhan in East Lombok (Steward 2017).

Lombok's agricultural products are dominated by rice, cassava, cotton, tobacco, soybeans, corn and chilies (BPS 2022). The West Nusa Tenggara Provincial Government has been promoting economic diversification, particularly in the tourism sector. Previously, tourism in Lombok was mainly concentrated along the west coast, especially in the Senggigi resort area and along the northern coastline, which features a series of stunning small islands (gili). However, interest in the south coast has increasingly grown in recent years, particularly around the Kuta Beach area of Lombok, a popular spot for surfers, and the surrounding coastal areas. This growth has been further supported by the establishment of the Mandalika Specific Economic Zone, which offers various luxury facilities, star hotels, and even an international racing circuit. Despite its many tourist attractions, Lombok receives fewer tourists compared to Bali (Steward 2017).

Data collection

Primary data collection was carried out in April 2018, several months before the earthquake that devastated Lombok in early August 2018. A total of 35 respondents were interviewed, most of whom were women under the age of 30. Respondents were selected through purposive sampling (Tongco 2007), with five women chosen from each surveyed village. The decision to focus exclusively on women, including young mothers, was based on their critical role in determining the family food menu. Verbal informed consent was obtained prior to the interviews (ISE 2006). The Food Frequency Questionnaires (FFQs) were employed to gather information on respondents' plant food consumption. This included details on commonly consumed plant foods, their edible parts, whether they were wild or cultivated, and their consumption frequency, which was categorized into eight frequency classes: seasonal, monthly, 1-3 times a month, weekly, 2-3 times a week, 4-6 times a week, daily, and 2-3 times a day.

The plant specimens were identified at Hortus Botanicus Baliensis (THBB), Bali Botanical Garden, Indonesia. Plant nomenclature followed the Plants of the World Online (POWO 2023). The plant parts (botanicals) and their biological activities referred to one of the most recent compendia of edible plants (Lim 2012, 2013a, 2013b, 2014a, 2014b, 2016). In this study context, the term 'plant part', 'edible part' and 'botanical' was used interchangeably.

Data Analysis

The general strategy of quantitative analyses was based on describing biocultural traits from the set of plant parts cited in FFQs by cluster analysis and on defining their meanings and behaviors in the dietary habits of the traditional communities. A biocultural trait then represented a subset of plant parts consumed with similar frequencies. The data set was obtained by merging the results of FFQs. Regarding the pros and cons of FFQS, as mentioned in the background section, it is important to note the method's inaccuracies, particularly in the estimation of dietary intake. However, FFQs remain effective in describing overall food patterns.

The subsequent steps of quantitative analyses are described in detail below.
A matrix of 77 botanicals, categorized by the numbers of citations across eight frequency classes, was used to perform multivariate analyses of the FFQs to identify bio-cultural traits through clustering. The analyses followed these steps:

1) Cluster analysis: Botanicals were grouped using a complete linkage algorithm (Anderberg 1973) based on a chord distance matrix between objects (Legendre & Legendre 2012). This allowed for the identification of groups of botanicals with similar citation frequency classes by cutting the resulting dendrogram.
2) Principal Component Analysis (PCA): PCA was conducted based on correlation coefficients between frequency classes (Legendre & Legendre 2012). The biplot method was used to display the ordination of botanicals positions, related groups, and frequency classes according to the first two principal components (Gabriel 1971). The information about the membership of plant parts to the groups was also overlapped to the same ordination diagram.
3) Definition of bio-cultural traits: Bio-cultural traits were identified and described by interpreting botanical groups (obtained in step 1) that showed similar use patterns, following the approach suggested by Sujarwo *et al*. (2019). The meaning of each group was determined by calculating the average citation percentages in each frequency class (Sujarwo *et al*. 2019).

All multivariate analyses were carried out using the Ginkgo software (De Caceres *et al*. 2007).

Results

Diversity of plants used as food

The set of plant food items obtained from the FFQs (Supplementary Materials, Table S1) in the Sasak traditional villages included 77 botanicals belonging to 68 plant species and 33 families. Most species were cultivated (57), while only 11 were wild. A few species had multiple edible parts, with *Carica papaya* having four distinct uses as food. The most represented family was Fabaceae, with 11 species (and 14 different botanicals), followed by Cucurbitaceae (5 species), and Brassicaceae and Myrtaceae (4 species each).

In regard to the plant parts used, more than half were fruits (53%), followed by leaves (21%), tubers/rhizomes/bulbs (10%) and seeds (8%) (Fig. 2). Other plant parts were relatively insignificant in quantity.

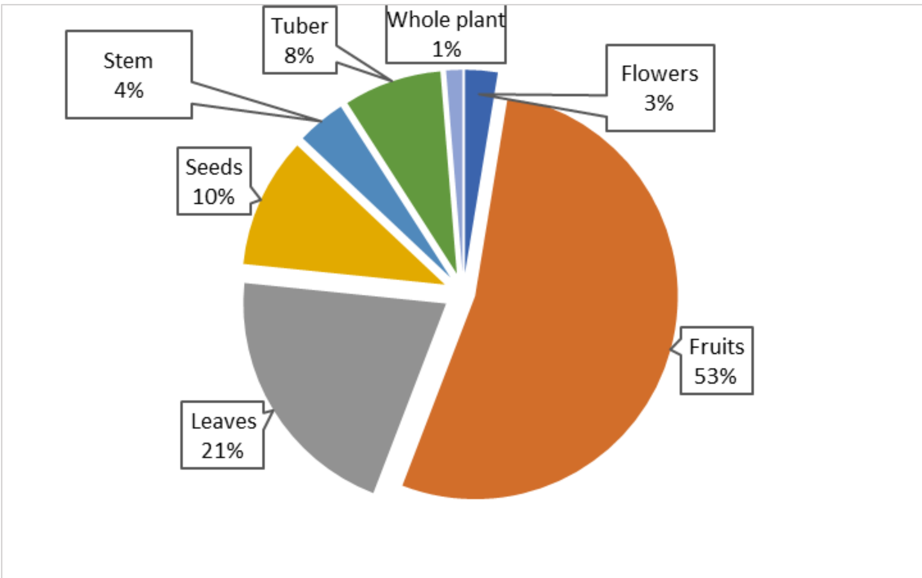

Figure 2. Percentage of plant parts used

Most botanicals were cooked before consumption (boiled, 48%; fried, 29%; steamed, 2%), with only 25% eaten raw. The villagers mainly used them as plain staples (10%), main dishes (50%), and side dishes (36%), with fewer used as snacks (3%) and condiments (1%). The supply chain of these food items relied heavily on traditional markets and home gardens, with rice being the only direct item sourced from local farmers' fields.

The FFQs dataset (Supplementary Materials, Table S3) showed citation frequencies for each botanical, corresponding to how often informants reported using them. Nine botanicals were consistently cited: the fruits of *Mangifera indica, Musa x paradisiaca, Nephelium lappaceum, Spondias dulcis, Salacca zalacca*, the leaves of *Ipomoea aquatica*, the seeds/grains of Oryza sativa, as well as the tubers of *Allium cepa*, and *Manihot esculenta*. Fifty-four botanicals were cited more than half the time, while 14 had fewer than ten citations (27% of cases). This reflects a diverse yet cohesive set of plant food items commonly shared among traditional Villages.

Several of botanicals documented in this study also displayed notable biological activities, with 80% of the items having antioxidant properties, 60% having anticancer and antimicrobial activities, and 50% showing anti-inflammatory effects (Fig. 3).

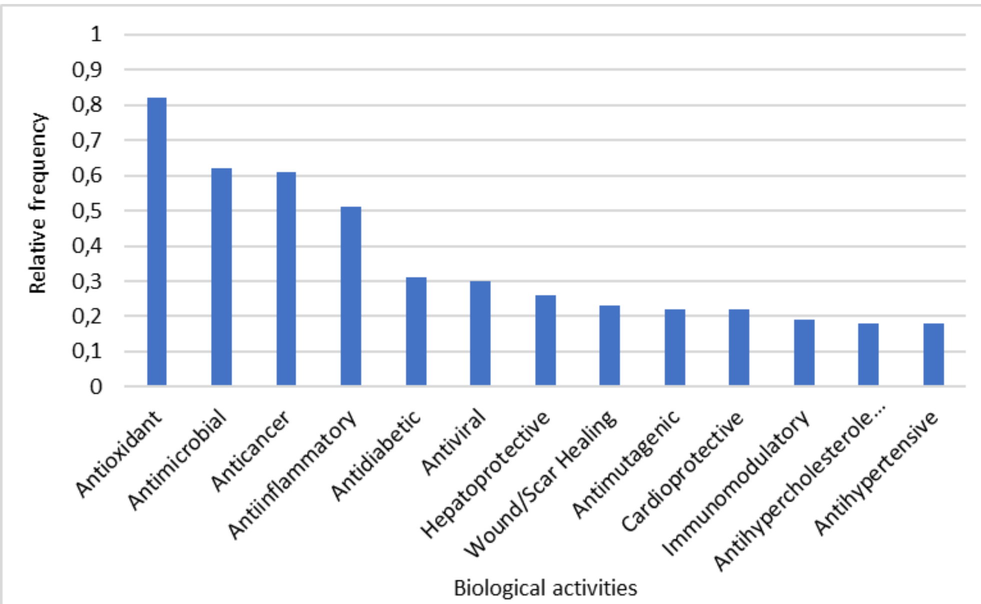

Figure 3. Relative frequencies of the most common biological activities among botanicals

Bio-cultural traits in dietary habits

The dendrogram cut (Fig. 4) obtained from the cluster analysis of the dataset matrix (Table S3) showed five groups of botanicals with similar consumption patterns throughout the year, based on the memory and traditions of the informants.

As shown in Table 1, the distribution of botanicals across the group varied: group 1 (39 elements), group 2 (1 element), group 3 (3 elements), group 4 (22 elements), and group 5 (12 elements).

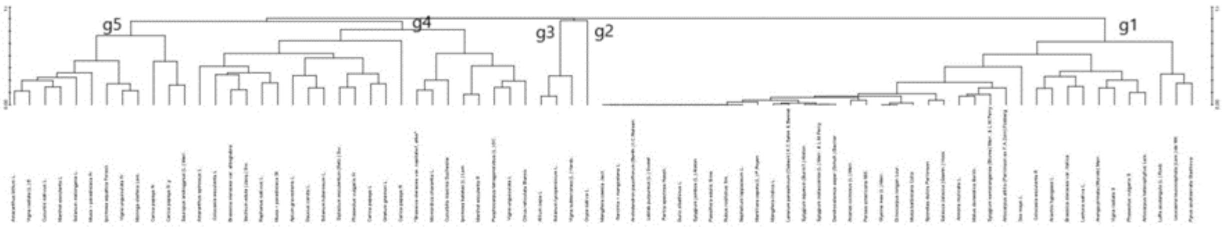

Figure 4. Dendrogram of botanicals from Table S3 (complete linkage based on chord distance matrix between botanicals), showing five groups identified by cutting

Table 1. Partition of botanicals in five groups from the dendrogram in Figure 4

Botanicals	**g-1 (s)**	**g-2 (a)**	**g-3 (d)**	**g-4 (i)**	**g-5 (w)**
Allium cepa L. (Tuber)	0	0	1	0	0
Amaranthus blitum L. (Leaves)	0	0	0	0	1
Amaranthus spinosus L. (Leaves)	0	0	0	1	0
Ananas comosus (L.) Merr. (Fruit)	1	0	0	0	0
Annona muricata L. (Fruit)	1	0	0	0	0
Apium graveolens L. (Leaves)	0	0	0	1	0
Arachis hypogaea L. (Seeds)	1	0	0	0	0
Archidendron pauciflorum (Benth.) I.C.Nielsen (Fruit)	1	0	0	0	0
Arenga pinnata (Wurmb) Merr. (Stem)	1	0	0	0	0
Artocarpus altilis (Parkinson) Fosberg (Fruit)	1	0	0	0	0
Artocarpus heterophyllus Lam. (Fruit)	1	0	0	0	0
[1]*Brassica oleracea* L. (Leaves)	0	0	0	1	0
[2]*Brassica oleracea* L. (Leaves)	0	0	0	1	0
[3]*Brassica oleracea* L. (Flower)	1	0	0	0	0
Carica papaya L. (Flower)	0	0	0	1	0
Carica papaya L. (Fruit)	0	0	0	0	1
Carica papaya L. (Leaves)	0	0	0	1	0
Carica papaya L. (Young Fruit)	0	0	0	0	1
Citrus reticulata Blanco (Fruit)	0	0	0	1	0
Colocasia esculenta (L.) Schott (Leaves)	0	0	0	1	0
Colocasia esculenta (L.) Schott (Tuber)	1	0	0	0	0
Cucumis sativus L. (Fruit)	0	0	0	0	1
Cucurbita maxima Duchesne (Leaves)	0	0	0	1	0
Daucus carota L. (Tuber)	0	0	0	1	0
Dendrocalamus asper (Schult.) Backer (Young Shoot)	1	0	0	0	0
Dimocarpus longan Lour. (Fruit)	1	0	0	0	0
Diplazium esculentum (Retz.) Sw. (Leaves)	0	0	0	1	0
Durio zibethinus L. (Fruit)	1	0	0	0	0
Garcinia mangostana L. (Fruit)	1	0	0	0	0
Glycine max (L.) Merr. (Seeds)	1	0	0	0	0
Gnetum gnemon L. (Leaves)	0	0	0	1	0
Ipomoea aquatica Forssk (Leaves)	0	0	0	0	1
Ipomoea batatas (L.) Lam (Tuber)	0	0	0	1	0
Lablab purpureus (L.) Sweet (Seeds)	1	0	0	0	0
Lactuca sativa L. (Leaves)	1	0	0	0	0
Lansium parasiticum (Osbeck) K.C.Sahni & Bennet (Fruit)	1	0	0	0	0
Leucaena leucocephala (Lam.) de Wit (Fruit)	1	0	0	0	0
Luffa acutangula (L.) Roxb (Fruit)	1	0	0	0	0

Malus domestica (Suckow) Borkh. (Fruit)	1	0	0	0	0
Mangifera caesia Jack (Fruit)	1	0	0	0	0
Mangifera indica L. (Fruit)	1	0	0	0	0
Manihot esculenta Crantz (Leaves)	0	0	0	0	1
Manihot esculenta Crantz (Tuber)	0	0	0	1	0
Manilkara zapota (L.) P.Royen (Fruit)	1	0	0	0	0
Momordica charantia L. (Fruit)	0	0	0	1	0
Moringa oleifera Lam. (Leaves)	0	0	0	0	1
Musa × paradisiaca L. (Fruit)	0	0	0	0	1
Musa × paradisiaca L. (Stem)	0	0	0	1	0
Musa balbisiana Colla (Fruit)	1	0	0	0	0
Nephelium lappaceum L. (Fruit)	1	0	0	0	0
Oryza sativa L. (Seeds)	0	1	0	0	0
Parkia speciosa Hassk. (Fruit)	1	0	0	0	0
Passiflora edulis Sims (Fruit)	1	0	0	0	0
Persea americana Mill. (Fruit)	1	0	0	0	0
Phaseolus vulgaris L. (Fruit)	0	0	0	1	0
Phaseolus vulgaris L. (Seeds)	1	0	0	0	0
Psophocarpus tetragonolobus (L.) DC. (Fruit)	0	0	0	1	0
Pyrus pyrifolia (Burm.f.) Nakai (Fruit)	1	0	0	0	0
Raphanus raphanistrum subsp. *sativus* (L.) Domin (Tuber)	0	0	0	1	0
Rubus rosifolius Sm. (Fruit)	1	0	0	0	0
Salacca zalacca (Gaertn.) Voss (Fruit)	1	0	0	0	0
Breynia androgyna (L.) Chakrab. & N.P.Balakr. (Leaves)	0	0	0	0	1
Sicyos edulis Jacq. (Fruit)	0	0	0	1	0
Solanum lycopersicum L. (Fruit)	0	0	1	0	0
Solanum melongena L. (Fruit)	0	0	0	0	1
Solanum tuberosum L. (Tuber)	0	0	0	1	0
Spondias dulcis Parkinson (Fruit)	1	0	0	0	0
Syzygium aqueum (Burm.f.) Alston (Fruit)	1	0	0	0	0
Syzygium jambos (L.) Alston (Fruit)	1	0	0	0	0
Syzygium malaccense (L.) Merr. & L.M.Perry (Fruit)	1	0	0	0	0
Syzygium samarangense (Blume) Merr. & L.M.Perry (Fruit)	1	0	0	0	0
Vigna radiata (L.) R.Wilczek (Seeds)	1	0	0	0	0
Vigna radiata (L.) R.Wilczek (Sprout)	0	0	0	0	1
Vigna subterranea (L.) Verdc. (Seeds)	0	0	1	0	0
Vigna unguiculata subsp. *sesquipedalis* (L.) Verdc. (Fruits)	0	0	0	0	1
Vigna unguiculata subsp. *sesquipedalis* (L.) Verdc. (Leaves)	0	0	0	1	0
Zea mays L. (Fruit)	1	0	0	0	0

[1,2,3]Share the same scientific name but are distinguished by their vernacular name: [1]Sawi, [2]Kol, [3]Brokoli.
s=seasonally; a=always; d=daily; i=infrequently; w=weekly

The sequence of these groups according to their frequencies of consumption over the year was illustrated using PCA. The ordination scattergram (Fig. 5) displayed a gradient of increasing frequencies, from seasonal to three times per day, with clear separation between the groups. The group sequence along the temporal gradient of consumption was: 1, 4, 5, 3, 2. This order and the relative abundance of citations per frequency class (Fig. 6), allowed us to assign a broad temporal meaning to the typical consumption of each group. Group 1 included botanicals often consumed seasonally, group 4 infrequently, group 5 weekly, group 3 daily, and group 2 always. These groups of botanicals were assumed as bio-cultural traits in dietary habits, representing recurring consumption patterns over specific periods of the year. It is interesting to note that rice was the only botanical in group 2 (always), highlighting its importance and peculiarity in traditional villages.

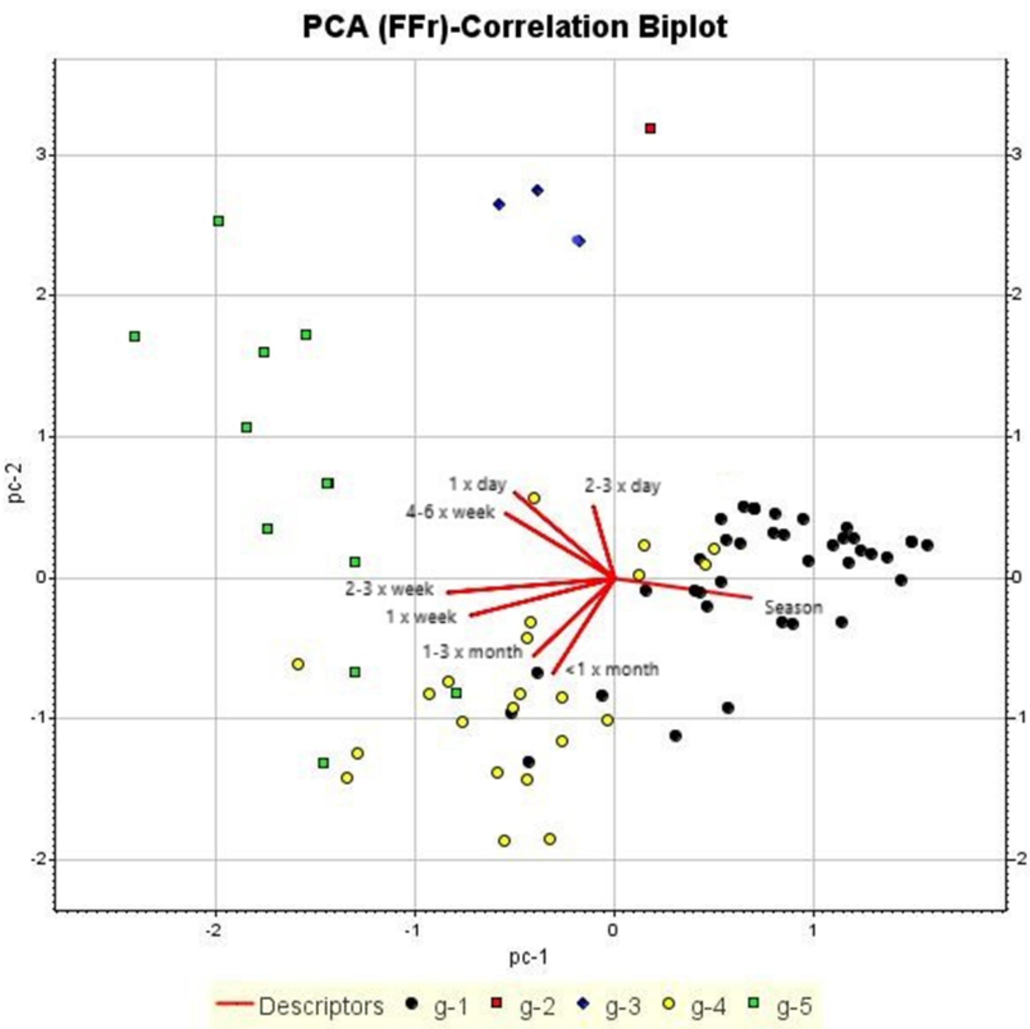

Figure 5. Principal Component Analysis of reported botanicals (Table S3). The first two components explain 64% of total variance. The partition in Table 1 is overlapped with scattergram of the first two principal components

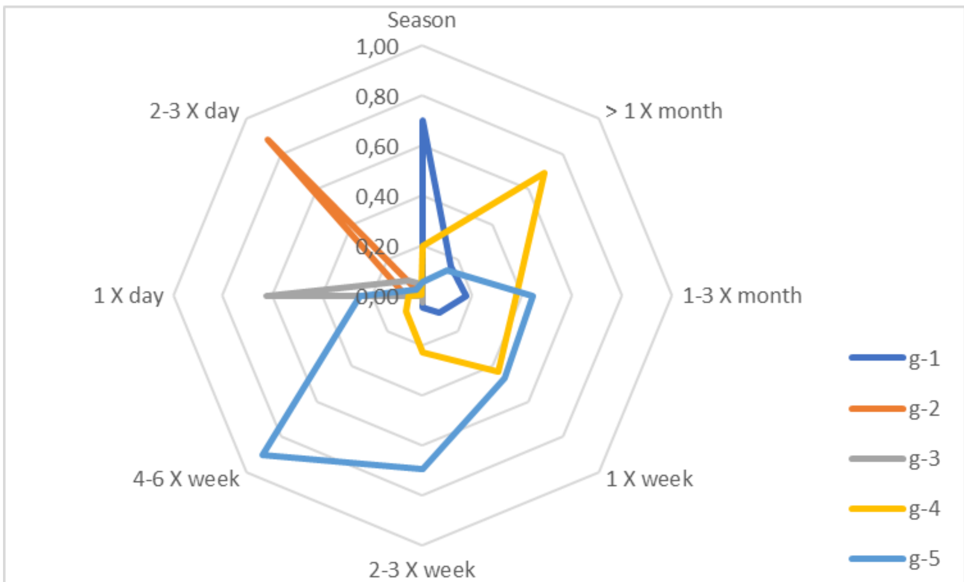

Figure 6. Relative abundance of citations per frequency class of groups in Table 1

According to the sequence of bio-cultural traits, it was possible to describe a consumption behaviour of different plant parts and foods types throughout the year, explaining dietary habits in traditional villages (Fig. 7 and Fig. 8). Fruits were mainly seasonal but sometimes consumed weekly or daily; seeds were always present in the diet; tubers/bulbs/rhizomes were significant both daily and infrequently; while leaves were most often consumed weekly and infrequently (Fig. 7). Regarding food types, botanical in a standard meal was typically present only as plain staple (Fig. 4). The consumption of plants in main dishes was the highest on a weekly basis, with slightly less frequency on an infrequent basis (Fig. 8). Botanicals-based side dishes reached their maximum consumption seasonally, while condiments and snacks made from plants were available daily.

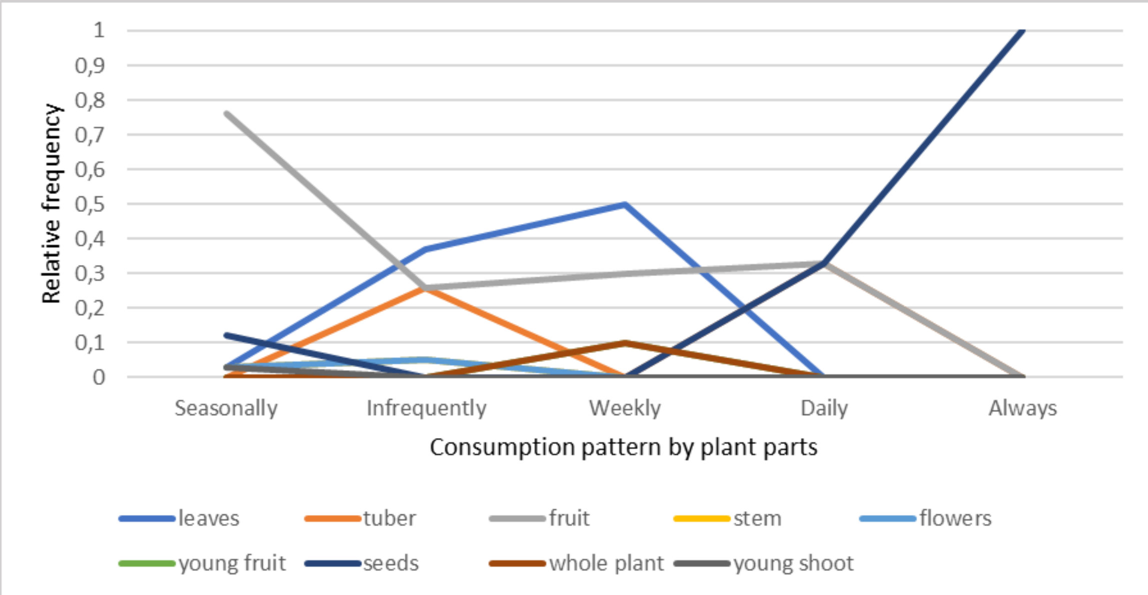

Figure 7. Relative frequencies of plant parts consumption in the bio-cultural traits

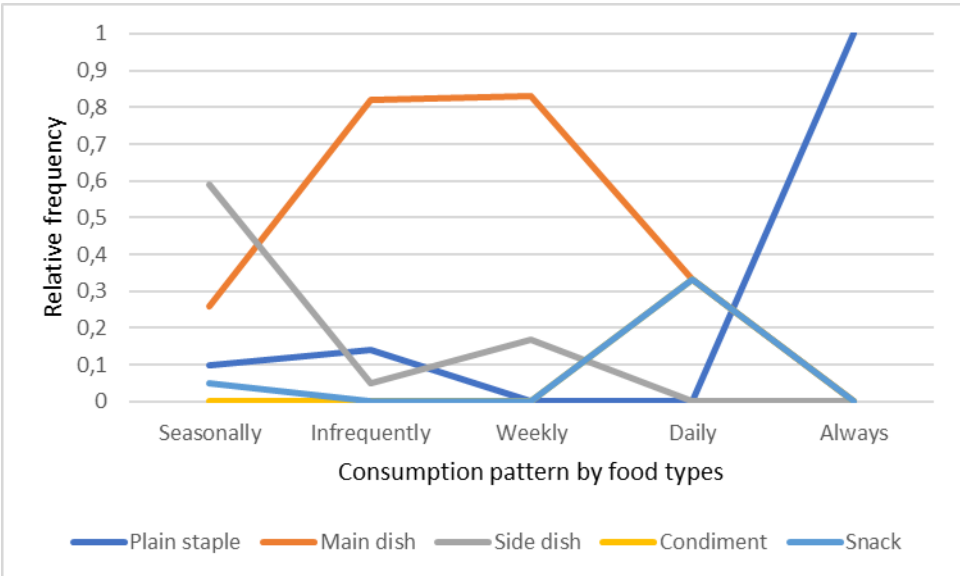

Figure 8. Relative frequencies of food types in the bio-cultural traits

The temporal sequence of traits also allowed us to define two types of botanical contributions to the diet. The primary contribution, observed in the regular diet in a week (traits: always, daily, and weekly), involved a limited number of botanicals (16). In contrast, the secondary contribution was characterized by seasonal and infrequent dietary variations, utilizing 62 different plant parts (Fig. 9 and Table 2). This secondary contribution added dietary diversity — particularly in side dishes, main dishes, and staples—to an otherwise simple pattern of plant consumption.

Table 2. Number of food types in the primary and secondary dietary contributions of botanicals in traditional villages

Dietary Contribution	Plain staple	Main dish	Side dish	Condiment	Snack
Primary	1	11	2	1	1
Secondary	7	28	24	0	2

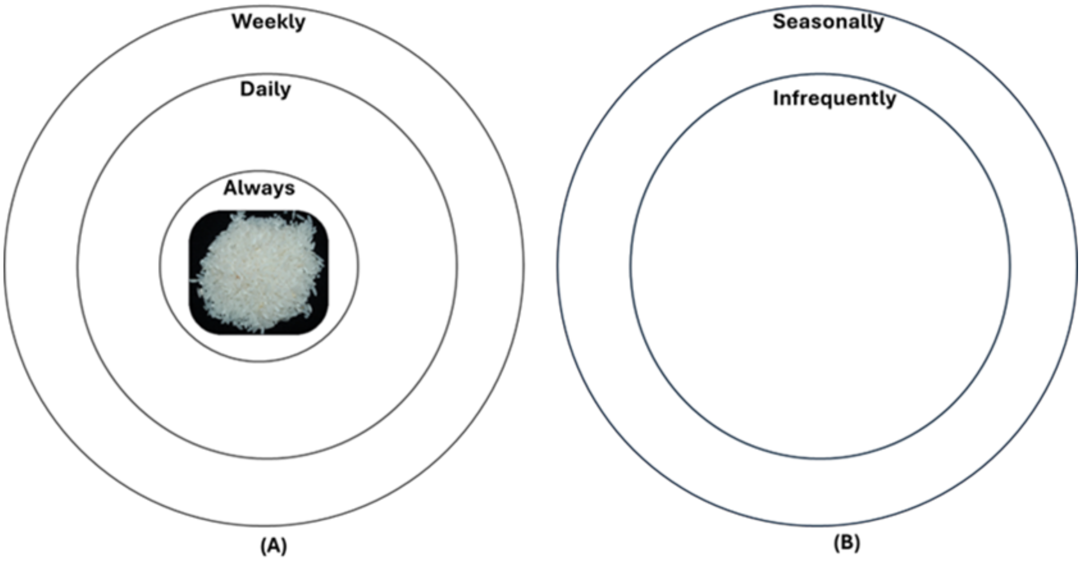

Figure 9. Illustration of bio-cultural traits in the (A) primary and (B) secondary contributions of botanicals. Rice is the key botanical associated with bio-cultural traits in the primary contribution

Discussion

Plant-based food of Sasak traditional villages

Plant consumption patterns suggested a shared bio-cultural knowledge among traditional villages across the island, maintained predominantly by women and reflected in local cuisine and the common use of botanicals. The selection of only female respondents in this study represented their central role in preserving native dietary habits and traditions. In Sasak traditional villages, women are primarily responsible for managing the family's diet, making meal choices that align with the household's financial situation (Sujarwo 2019), as well as fostering their children' healthy development.

The present study documented 77 botanicals from 68 plant species (Table 1), which is fewer than 147 plant species previously reported in a study on local cuisine in Lombok (Sukenti *et al.* 2016). However, 32 plants species were common in both studies (Supplementary Materials, Table S2). The discrepancy in the number and types plant species recorded may be attributed to the previous study's focus on plants used in main dishes, which resulted in the inclusion of many spices but the exclusion of fruit species. In contrast, our study emphasized on consumption patterns over different time frames (short- and long-term patterns), capturing variations that include fruit intake (mostly consumed seasonally), such as durian (*Durio zibethinus*), mangosteen (*Garcinia mangostana*), apple (*Malus domestica*), sapodilla/**sawo** (*Manilkara zapota)*, and others (Table S1), even though these fruits are commonly found across the Island. We excluded chili from our list of documented food plants because of its ubiquitous use in local cooking. Notably, the name "Lombok" itself means chili in Javanese (Sujarwo 2019), highlighting its central role in the local cuisine.

Differences between our study and the previous one by Sukenti *et al.* (2016) may also result from the variations in food preferences driven by tourism. Tourists' food interests can influence the culinary offerings in popular tourists areas like Lombok (Mak *et al.* 2012). This cultural shift, caused by globalization (Sujarwo *et al.* 2014), increases the risk of losing the core set of bio-cultural traditions of the native population in Lombok. Nonetheless, plant-based foods in Sasak villages continue to demonstrate a significant degree of uniformity and uniqueness, rooted in traditional food practices. This uniformity persists despite environmental differences between Lombok's southern and northern regions, which affects habitat and resource availability. The southern region is considered drier with limited water sources compared to the northern part (Sujarwo 2019). Most food plants, including fruits, are cultivated, reflecting the similarities in food crops among Lombok farmers due to their high market value. Meanwhile the use of wild or semi-wild plants varies based on habitat and local preferences.

Our finding that fruits being the most consumed plant part aligns with ethnobotanical reports in Indonesia (Suwardi *et al.* 2023) and other regions (Duguma 2020), suggesting a perceived better taste of fruits compared to other plant parts. Nonetheless, leaves are also commonly consumed after fruits. For example, the leaves of *Moringa oleifera* are frequently used in vegetable soups that are popular across Lombok. This plant is widely available, and rich in essential nutrients such as protein, fiber, calcium, iron, and vitamin C (Rahayu *et al* 2024, Vélez-Gavilán 2017). Other plants documented in this study also serve as good nutrient sources, including the fruit of *Leucaena leucocephala*, which contains protein, fiber, calcium, and zinc; the leaves of *Breynia androgyna*, which are rich in iron, zinc, and vitamin C; and the fruit of *Durio zibethinus* and leaves of *Manihot esculenta*, both of which are good sources of vitamin C (Rahayu *et al* 2024).

While these food plants can provide significant nutritional benefits for the people of traditional Sasak villages, their seasonal availability, particularly for fruits, can limit access. During off-seasons or early in the season, these fruits sold in the traditional market often expensive (Sujarwo 2019), making them unaffordable for some villagers (Uauy & Monteiro 2004). This observation supports a recent global study linking low fruit intake to affordability issues (Miller *et al.* 2016). Furthermore, although these botanicals offer essential nutrients, their consumption alone is insufficient to prevent stunting among Lombok's population, as stunting is also related to the overall balance of nutritional intake during infancy (Ekawidyani *et al.* 2015, Karuniawaty *et al.* 2020, Nurbaiti *et al.* 2021).

In addition to their dietary importance, edible plant species are widely recognized for their significant health benefits, owing to their well-documented biological and pharmacological effects (Smith *et al.* 2019, Punchay *et al.* 2020, Rahayu *et al.* 2022). Accordingly, some botanicals documented in this study have been reported to exhibit various biological activities (Lim 2012, 2013a, 2013b, 2014a, 2014b, 2016). In the traditional Sasak communities, many of these plant-based food sources are rich in antioxidants, and have anticancer, antimicrobial, and anti-inflammatory properties, which are important for maintaining the health of the communities.

Traditional uses of the most frequent botanicals in the local cuisine

As a bio-cultural signature of daily life and special events, the plant species and botanicals documented in this study characterize the cuisine of traditional villages in Lombok (Sujarwo *et al.* 2019). The most frequently used plant, rice (*Oryza sativa*), is a staple food for Indonesians (Taylor 2003), including the traditional Sasak community of Lombok, where it is typically prepared by boiling or steaming and often served with dishes containing pulses, vegetables, fish, or meat.

Water spinach (*Ipomoea aquatica*) is another widely used plant as it is a key ingredient in some of Lombok's most popular dishes, such as *pelecing* **kangkung** and **urap** (Sujarwo 2019). In **Pelecing kangkung***,* water spinach leaves (locally known as **kangkung**) are boiled and served with fresh bean sprouts coated in a spicy tomato sauce. In **urap** —also called **serebuk** in the Central Lombok area — boiled water spinach leaves and other vegetables are mixed with seasoned grated coconut. Several other botanicals feature prominently in popular plant-based dishes in the area. For instance, **lalapan**, a mixed vegetable plate commonly served with spicy chili sauce, includes fresh cabbage (*Brassica oleracea*), green beans (*Phaseolus vulgaris)*, and cucumber (*Cucumis sativus*). **Beberok,** a traditional Sasak dish, is made from chopped cowpea (*Vigna unguiculata)* and eggplant (*Solanum melongena)*, covered in a chili sauce made from a mixture of tomatoes, chilies, shallots, and lime. Nearly all traditional chili sauces in Lombok are mixed with grilled shrimp paste.

Lombok's cuisine also features dishes using spices and coconut milk, such as **ares,** a traditional dish made from the inner stem of the banana tree (*Musa × paradisiaca*). Another example is **olah-olah**, a coconut milk-based dish made from boiled vegetables, with the specific vegetables depending on local availability. In South Lombok, **olah-olah** is typically made from the heart of banana flowers, while in the central to northern areas, it is prepared with **pakis** (*Diplazium esculentum*) and cowpea (*Vigna unguiculata*), finely chopped. The culinary diversity in the Central Lombok area, especially in the southern part, is influenced by the region's geography, which allows for a combination of produce from gardens and rice fields with products from the sea. The dry climate also contributes to unique culinary practices, encouraging the use of dried grains or secondary crops harvested during the rainy season for consumption in the dry season.

Lombok is also known for its **taliwang** chicken, a dish made from small to medium-sized young local chickens. The free-range chicken is grilled with a special chili sauce made from coconut milk and spices, similar to curry sauce, and often served with the traditional chili sauce. Another notable dish is **pelecing** chicken, where the chicken is first grilled, then cut into small pieces, fried, and sautéed with red chili sauce, sliced tomatoes and additional lime leaves and fruit (*Citrus x amblycarpa*).

Patterns of plant consumption according to different bio-cultural habits in the diet

The approach based on bio-cultural traits obtained from FFQs was effective in identifying varying dietary habits throughout the year, reflecting the bio-cultural customs, environmental conditions, biological needs, and economic resources of the traditional Sasak communities. Some bio-cultural habits contributed to establishing a monotonous weekly routine of botanical consumptions, whereas others increased the variability of plant-based diet across seasons and throughout the year. Two plant consumption patterns emerged, categorized as primary and secondary contributions.

In the weekly cycle, the staple was consistently white rice, which is unsurprising given that it is a key component of diets throughout Asia (Ang *et al.* 1999). Rice consumption in Indonesia has decreased over the past three decades partly due to the rise of instant noodles (Sakai *et al*. 2022), yet it remains the main energy source for most citizens (Chaudhari *et al.* 2018). Rice can inhibit zinc absorption, contributing to stunting syndrome when combined with insufficient parental care and chronic infections (Irawati *et al.* 2022). However, the main cause of stunting is inappropriate feeding practices for infants and children (Ekawidyani *et al.* 2015, Karuniawaty *et al.* 2020, Nurbaiti *et al.* 2021). The additional daily energy contribution came from peanuts snacks, while onion and tomato, whether used as condiments or main ingredients, typically appeared in meals at least once per day. These foods, available in the traditional village markets, are affordable and represent functional foods that provide multiple health benefits (Canene-Adams *et al.* 2005, Arya *et al*. 2016, Chadorshabi *et al*. 2022). Weekly variability was achieved by rotating several common plant-based main dishes, including vegetables like *Brassica oleracea*, *Cucurbita maxima*, *Momordica charantia*; fruits such as *Citrus reticulata*, and tuberous carbohydrate like *Colocasia esculenta*.

In the annual cycle, the secondary contribution from fruit plants such as *Durio zibethinus*, *Garcinia mangostana*, *Mangifera indica*, *Nephelium lappaceum*, *Salacca zalacca*, and *Spondias dulcis* follow a seasonal cycle aligned with species phenology and cultural events including ceremonies and festivals. The Sasak community's reliance on seasonal food plants to supplement their staple of white rice reflects a dual-cycle consumption pattern that enhances dietary diversity and nutritional adequacy. This temporal sequence of primary and secondary contributions aligns with traditional dietary practices in Lombok and Indonesia, such as **nasi campur —** a dish that combines small portions of diverse dishes with rice that enhances dietary diversity and desirability (Palupi & Abdillah 2019).

The dual-cycle pattern practiced by the Sasak communities mirrors Indigenous food systems globally, where the interplay between primary staples and secondary food plants fosters sustainability and resilience (Marrero *et al*. 2023). For example, Andean communities in South America cultivate potatoes and quinoa as primary staples, with wild foraged plants and seasonal fruits contributing to nutritional variety (Argumedo *et al*., 2021). Similarly, the "Three Sisters" planting system, practiced by Indigenous North American tribes, integrates corn as the staple crop, with beans and squash serving as secondary crops; the intercropping method enhances soil fertility while yielding more energy and protein than monocultures planted in the same area (Mt. Pleasant, 2016). In Africa, millet or sorghum serves as the dietary core, while secondary foraged plants, such as wild greens and fruits, provide nutritional resilience during lean seasons (Swiderska *et al*., 2022). These examples illustrate how this biocultural trait sustains biodiversity, preserves traditional knowledge, and fortifies local food sovereignty (Gepts 2023).

Conclusion

Indigenous People embody a fundamental aspect of the world's cultural and bio-cultural diversity through their unique cultures, customs, and traditional ecological knowledge (TEK). This research illustrated the TEK of Sasak traditional villages to elucidate their dietary preferences and habits related to food plant consumption, using food frequency questionnaires (FFQs) and bio-cultural traits. While FFQs are typically employed in dietary intake research, their use in ethnobiological studies is less common. Applying FFQs to examine the dietary habits of a traditional community offered novel and valuable insights into its TEK.

Our findings reveal that dietary diversity in traditional Sasak communities was achieved through bio-cultural practices involving two types of botanical contributions. The primary contribution consisted of staple, while the secondary contribution added variety to simpler meals, particularly through side dishes and main dishes. Our findings further suggest that the uniform bio-cultural behavior of these villages, reflected in their food plant preferences and selections, has remained resilient against cultural erosion from globalization. Plant-based foods continue to play a pivotal role in the diet of these traditional villages, characterized by a rural environment, local production, and supply chains.

The approach based on bio-cultural traits, identified by groups of botanicals from FFQs, allowed us to describe the temporal dynamics of the plant consumption system in these communities, highlighting both cultural aspects and TEK. Recognizing these ethnic dietary aspects is essential for promoting the health and well-being of local populations, achieving the Sustainable Development Goals, preserving the true cultural identity of the Sasak people, and maintaining the bio-cultural diversity of indigenous peoples.

Declarations

Ethics approval and consent to participate: The study was conducted following ISE Code of Ethics Guidelines (ISE 2008). Verbal consent was acquired before conducting interviews.
Consent for publication: Not applicable
Availability of data and materials: All supporting data are summarized in the main and supplementary tables within the article.
Competing interests: The authors declare that they have no conflict of interest.
Funding: The work was funded by the Research Center for Biology, Indonesian Institute of Sciences (LIPI), which has since merged into the National Research and Innovation Agency (BRIN). It was supported under the Indonesian Biodiversity Strategy and Action Plan (IBSAP) program in 2018.
Author contributions: W.S. conceptualization, methodology, data curation, writing original draft, review and editing, and project administration. K.S. review. Y.Y.S.R. review and editing. N.L. data curation. A.P.K. review. V.Z. conceptualization, methodology, writing original draft, review and editing. All authors reviewed the manuscript.

Acknowledgements

We thank everyone who contributed to this study and shared their knowledge.

Literature cited

Alcorn JB. 1981. Factors influencing botanical resource perception among the Huastec: Suggestions for future ethnobotanical inquiry. Journal of Ethnobiology 1(2): 221-230.

Anderberg MR. 1973. Cluster analysis for applications: probability and mathematical statistics: a series of monographs and textbooks (Vol. 19). Academic Press, London, U.K.

Ang CY, Liu K, Huang YW. 1999. Asian foods: Science and technology. CRC Press, Boca Raton, U.S.

Argumedo A, Song Y, Khoury CK, Hunter D, Dempewolf H, Guarino L, de Haan S. 2021. Biocultural Diversity for Food System Transformation Under Global Environmental Change. Front. Sustain. Food Syst. 5:685299.

Arya SS, Salve AR, Chauhan S. 2016. Peanuts as functional food: a review. Journal of Food Science and Technology 53: 31-41.

Barthel S, Crumley CL, Svedin U. 2013. Bio-cultural refugia safe guarding diversity of practices for food security and biodiversity. Global Environmental Change 23: 1142-1152.

Blust RA. 2013. The Austronesian languages. Rev. Ed. Australian National University, Canberra, Australia.

BPS. Provinsi Nusa Tenggara Barat Dalam Angka. 2022. Main report. Badan Pusat Statistik Press, Mataram, Indonesia.

Canene-Adams K, Campbell JK, Zaripheh S, Jeffery EH, Erdman JJ. 2005. The tomato as a functional food. The Journal of Nutrition 135(5): 1226-1230.

Chadorshabi S, Hallaj-Nezhadi S., Ghasempour Z. 2022. Red onion skin active ingredients, extraction and biological properties for functional food applications. Food Chemistry 386: e132737.

Chaudhari PR, Tamrakar N, Singh L, Tandon A, Sharma D. 2018. Rice nutritional and medicinal properties: A review article. Journal of Pharmacognosy and Phytochemistry 7(2): 150-156.

De Caceres M, Oliva F, Font X, Vives S. 2007. Ginkgo, a program for non-standard multivariate fuzzy analysis. Advances in Fuzzy Sets and Systems 2(1): 41-56.

Duguma HT. 2020. Wild edible plant nutritional contribution and consumer perception in Ethiopia. International Journal of Food Science e2958623.

Ekawidyani KR, Wibowo L, Rospita L, Wiradnyani LA, Manjilala M, Putriani SD, Marini R. 2015. Child feeding pattern during transitional period (6-8 months) in Jonggat Sub District, Central Lombok, West Nusa Tenggara. Jurnal Gizi dan Pangan 10(2): 101-108.

Eng CW, Lim SC, Ngongo C, Sham ZH, Kataria I, Chandran A, Mustapha FI. 2022. Dietary practices, food purchasing, and perceptions about healthy food availability and affordability: a cross-sectional study of low-income Malaysian adults. BMC Public Health 22: e192.

Engelberger L, Johnson E, Fanzo J, Hunter D, Borelli T. 2013. Traditional foods of the Pacific: Go Local, a case study in Pohnpei, Federated States of Micronesia. Diversifying food and diets: using agricultural biodiversity to improve nutrition and health. Routledge, London, U.K.

Farshchi HR, Macdonald I, Madjd A, Taylor MA. 2017. Benefits and limitations of traditional self-report instruments. In: Schoeller DA, Westerterp M. (eds). Advances in the Assessment of Dietary Intake, first ed. CRC Press, Boca Raton, U.S, Pp. 1-17.

Gabriel KR. 1971. The biplot graphic display of matrices with application to principal component analysis. Biometrika 58(3): 453-467.

Gepts P. 2023. Biocultural diversity and crop improvement. Emerg Top Life Sci. Dec 13;7(2):151-196.

In: Pearce PL, Oktadiana H. (eds). Delivering Tourism Intelligence: From Analysis to Action. Emerald Publishing Limited, Leeds, U.K, Pp. 299-312.

Inglis J. 1993. Traditional ecological knowledge: Concepts and cases. IDRC, Ottawa, Canada.

Irawati D, Nurbaiti L, Ekawanti A. 2022. Zinc deficiency among adolescence in stunting locus area, Lombok, Indonesia. Advances in Health Sciences Research, volume 46. In: Proceedings of the 2nd Global Health and Innovation in conjunction with 6th ORL Head and Neck Oncology Conference (ORLHN 2021). Atlantis Press, Pp. 301-307.

ISE. ISE Code of Ethics (with 2008 additions). 2006. International Society of Ethnobiology. http://ethnobiology.net/code-of-ethics/ (Accessed 7/1/ 2024).

Johns T, Sthapit BR. 2004. Biocultural diversity in the sustainability of developing-country food systems. Food and Nutrition Bulletin 25(2): 143-155.

Karuniawaty TP, Sari LS, Wiweko A, Karmila I. 2020. Implementation of educative boardgame to improve knowledge, attitude and practice of complementary feeding in stunting locus at Central Lombok. American Journal of Pediatrics 6(3): 172-181.

Kuhnlein HV, Erasmus B, Spigelski D. 2009. Indigenous Peoples' food systems: The many dimensions of culture, diversity and environment for nutrition and health. Food and Agriculture Organization of the United Nations (FAO), Rome, Italy.

Kuhnlein HV, Receveur O. 1996. Dietary change and traditional food systems of indigenous peoples. Annual Review of Nutrition 16(1): 417-442.

Legendre P, Legendre L. 2012. Numerical ecology (third ed). Elsevier.

Lim TK. 2012. Edible medicinal and non-medicinal plants: Volume 1-5, Fruits. Springer, Dordrecht, Netherlands.

Lim TK. 2013a. Edible medicinal and non-medicinal plants: Volume 6, Fruits. Springer, Dordrecht, Netherlands.

Lim TK. 2013b. Edible medicinal and non-medicinal plants: Volume 7, Flowers. Springer, Dordrecht, Netherlands.

Lim TK. 2014a. Edible medicinal and non-medicinal plants: Volume 8, Flowers. Springer, Dordrecht, Netherlands.

Lim TK. 2014b. Edible medicinal and non-medicinal plants: Volume 9, Modified Stems, Roots, Bulbs. Springer, Dordrecht, Netherlands.

Lim TK. 2016. Edible medicinal and non-medicinal plants: Volume 10-12, Modified Stems, Roots, Bulbs. Springer, Dordrecht, Netherlands.

Maffi L. 2001. On biocultural diversity: Linking language, knowledge, and the environment. Institute Press, Washington DC, U.S.

Mak AHN, Lumbers M, Eves A. 2012. Globalisation and food consumption in tourism. Annals of Tourism Research 39: 171-196.

Marrero A, Nicoson C, Mattei J. 2023. Food laborers as stewards of island biocultural diversity: reclaiming local knowledge, food sovereignty, and decolonization. Front. Sustain. Food Syst. 7:1093341.

McKinnon J. 1996. Vessels of life: Lombok earthenware. Saritaksu, Denpasar, Indonesia.

Miller V, Yusuf S, Chow CK, Dehghan M, Corsi DJ, Lock K, Popkin B, Rangarajan S, Khatib R, Lear SA, Mony P, Kaur M, Mohan V, Vijayakumar K, Gupta R, Kruger A, Tsolekile L, Mohammadifard N, Rahman O, Rosengren A, Avezum A, Orlandini A, Ismail N, Lopez-Jaramillo P, Yusufali A, Karsidag K, Iqbal R, Chifamba J, Oakley SM, Ariffin F, Zatonska K, Poirier P, Wei L, Jian B, Hui C, Xu L, Xiulin B, Teo K, Mente A. 2016. Availability, affordability, and consumption of fruits and vegetables in 18 countries across income levels: findings from the Prospective Urban Rural Epidemiology (PURE) study. Lancet Global Health 4: e695-e703.

Mt.Pleasant J. 2016. Food Yields and Nutrient Analyses of the Three Sisters: A Haudenosaunee Cropping System. Ethnobiology Letters 7(1): 87-98.

Nurbaiti L, Taslim NA, Hatta M, Bukhari A. 2021. Evaluation of feeding practices for infants and children (PMBA) for stunting children in Lombok. Annals of the Romanian Society for Cell Biology 25(1): 2019-2027.

Ocké MC. 2013. Evaluation of methodologies for assessing the overall diet: Dietary quality scores and dietary pattern analysis. Proceedings of the Nutrition Society, volume 72. In: Conference on 'Translating nutrition: integrating research, practice and policy', Symposium1: Innovation in diet and life style assessment. Cambridge University Press, Cambridge, U.K, Pp 191-199.

Palupi S, Abdillah F. 2019. Local Cuisine as a Tourism Signature: Indonesian Culinary Ecosystem.

POWO. Plants of the World Online. 2024. Royal Botanic Gardens, Kew. http://www.plantsoftheworldonline.org/ (Accessed 7/1/2024).

Punchay K, Inta A, Tiansawat P, Balslev H, Wangpakapattanawong P. 2020. Nutrient and mineral compositions of wild leafy vegetables of the Karen and Lawa communities in Thailand. Foods 9: 1-15.

Rahayu M, Keim AP, Nikmatullah M, Rustiami H, Susan D, Sujarwo W. 2021. The ethnoecology of Sisak people in Mandalika, Lombok Island: Local knowledge and wisdom in relation with land use. Jurnal Pendidikan IPA Indonesia 10(3): 407-415.

Rahayu YYS, Araki T, Rosleine D, Purwaningtyas RM. 2022. General practitioners' attitudes toward traditional Indonesian herbal medicine and integrative care in the universal health coverage system. Global Journal of Health Science 14: 82.

Rahayu YYS, Sujarwo W, Irsyam ASD, Dwiartama A, Rosleine D. 2024. Exploring unconventional food plants used by local communities in a rural area of West Java, Indonesia: ethnobotanical assessment, use trends, and potential for improved nutrition. Journal of Ethnobiology Ethnomedicine 20: 68.

Reynertson K, Mahmood K. 2015. Botanicals: Methods and techniques for quality and authenticity. CRC Press, Boca Raton, U.S.

Sakai Y, Rahayu YYS, Araki T. 2022. Nutritional value of canteen menus and dietary habits and intakes of university students in Indonesia 14:1911.

Smith E, Ahmed S, Dupuis V, Crane MR, Eggers M, Pierre M, Flagg K, Shanks CB. 2019. Contribution of wild foods to diet, food security, and cultural values amidst climate change. Journal of Agriculture, Food Systems, and Community Development 9: 1-24.

Steward I. 2017. The rough gate to Bali and Lombok. Rough Guides Ltd, New Delhi, India.

Sujarwo W, Arinasa IBK, Salomone F, Caneva G, Fattorini S. 2014. Cultural erosion of Balinese indigenous knowledge of food and nutraceutical plants. Economic Botany 68(4): 426-437.

Sujarwo W, Caneva G, Zuccarello V. 2019 Bio-cultural traits and cultural keystone species, a combined approach: an example of application about plants used for food and nutraceutical purposes in Aga Villages in Bali, Indonesia. Human Ecology 47: 917-929.

Sujarwo W. 2019. Sasak traditional villages: A tourism potential and conservation effort for culture and plants. Jurnal Masyarakat dan Budaya 21(2): 203-220.

Sukenti K, Hakim L, Indriyani S, Purwanto Y, Matthews P. 2016. Ethnobotanical study on local cuisine of the Sasak tribe in Lombok Island, Indonesia. Journal of Ethnic Foods 3(3): 189-200.

Suwardi AB, Syamsuardi, Mukhtar E, Nurainas. 2023. The diversity and traditional knowledge of wild edible fruits in Bengkulu, Indonesia. Ethnobotany research and Applications 25:15.

Swidersk, K, Argumedo A, Wekesa, C, Ndalilo, L, Song, Y, Rastogi, A, Ryan, P. 2022. Indigenous Peoples' Food Systems and Biocultural Heritage: Addressing Indigenous Priorities Using Decolonial and Interdisciplinary Research Approaches. Sust 14: 11311.

Taylor JG. 2003. Indonesia: Peoples and histories. Yale University Press, New Haven, U.S.

Tongco MDC. 2007. Purposive Sampling as a Tool for Informant Selection. Ethnobotany Research and Applications 5: 147-158.

Tryon D. 2006. Proto-Austronesians and major Austronesian subgroups. In: Bellwood P, Fox J, Tryon D. (eds). The Austronesians: Historical & comparative perspectives. Australian National University, Canberra, Australia.

Turner NJ, Plotkin M, Kuhnlein HV. 2013. Global environmental challenges to the integrity of Indigenous Peoples' food systems. In: Kuhnlein HV, Erasmus B, Spigelski D, Burlingame B. (eds.), Indigenous peoples' food systems and well-being: interventions and policies for healthy communities. FAO, Rome, Italy, Pp 23-38.

Turner NJ, Turner KL. 2007. Traditional food systems, erosion and renewal in Northwestern North America. Indian Journal of Traditional Knowledge 6(1): 57-68.

Uauy R, Monteiro CA. 2004. The challenge of improving food and nutrition in Latin America. Food and Nutrition Bulletin 25: 175-182.

UN. Sustainable Development Goals. 2023. https://www.un.org/sustainabledevelopment/sustainable-development-goals/ (Accessed 1/102023).

UN. United Nations declaration on the rights of indigenous peoples (A/RES/61/295). 2007. United nations.

Vélez-Gavilán J. Moringa oleifera (horse radish tree). 2017. CABI Compendium. https://doiorg/10.1079/cabicompendium.34868 (Accessed 31 /1/2024).

Waltz CL. 2011. Local food systems: Background and issues. Nova Science Publishers, Inc, New York, U.S.