Unearthing the "Lost" Andean Root Crop "Mauka" (*Mirabilis expansa* [Ruíz & Pav.] Standl.)

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Unearthing the "Lost" Andean Root Crop "Mauka" (*Mirabilis expansa* [Ruíz & Pav.] Standl.). Although recognized as part of the vibrant array of native roots and tubers that support farmers' livelihoods in the Andean region, the root vegetable "mauka" (*Mirabilis expansa* (Ruíz & Pav.) Standl.) is little known outside the scattering of communities where it is cultivated and is considered at risk of disappearance. Based on fieldwork carried out in Peru in 2016, this study documents ethnobotanical knowledge of mauka through interviews with 40 farmers across the regions of Ancash, Huánuco, Puno, and Amazonas. Further, it re-evaluates the distribution of the crop and explores opportunities for conservation. Mauka was found to be more widely distributed in Peru than previously thought, and a total of 21 germplasm specimens were collected for *ex situ* conservation, including one landrace from Puno that had not been previously described. Farmers reported a substantial decline in mauka cultivation in their communities 20–50 years ago, with its lack of commercial value cited as a major reason for abandonment. Promisingly, through facilitating an encounter between several of these farmers and chefs at the renowned Peruvian restaurant *Central*, we demonstrate that revaluing mauka as a gastronomic ingredient could incentivize ongoing cultivation.

Desenterrando La Raíz 'Perdida' De Los Andes "Mauka" (*Mirabilis expansa* [Ruíz & Pav.] Standl.). Aunque es conocida como una parte de la variedad de raíces y tubérculos nativos cultivados por agricultores de la región andina, la "mauka" (*Mirabilis expansa* (Ruíz & Pav.) Standl.) es poco usada fuera de las comunidades locales donde la gente se cultiva, y está en proceso de desaparecer. Este estudio está basado en trabajo de campo realizado en el Perú durante el 2016, documentando los conocimientos etnobotánicos sobre la mauka. Se baso en entrevistas con cuarenta agricultores en los departamentos de Ancash, Huánuco, Puno, y Amazonas. También se reevalúo la distribución de este cultivo y se exploró las posibilidades para su conservación. Se descubrió que la mauka está más ampliamente distribuida de lo que se pensaba. Se recolectaron un total de veintiún muestras de germoplasma para la conservación ex–situ, incluyendo un morofotipo no descrito en Puno. Los agricultores han informado sobre la disminución sustancial del cultivo en los últimos 20 a 50 años. Su valor comercial bajo es considerado como una de las principales razones para su abandono. Al facilitar un encuentro entre varios de estos agricultores y chefs del renombrado restaurante Peruano *Central*, demostramos que revalorizar la mauka como ingrediente gastronómico podría incentivar su cultivación nuevamente.

Key Words: Peru, Andes, ethnobotany, agrobiodiversity, crop conservation, cultural memory, gastronomy.

[1] Received 20 March 2019; accepted 12 July 2019; published online 14 August 2019

Electronic supplementary material The online version of this article (https://doi.org/10.1007/s12231-019-09467-y) contains supplementary material, which is available to authorized users.

Economic Botany, 73(4), 2019, pp. 443–460

Introduction

The rich legacy of agricultural diversity and associated ecological knowledge that typifies traditional Andean farming has been severely eroded (Shepherd 2017). Sadly, this is a trend experienced by smallholder farmers across the world, perpetuated at the global scale by our increasing dependence on a narrow range of food crops and raising due concerns over food security, nutrition, and environmental sustainability (Padulosi 2012). While considerable efforts have been made internationally to conserve crop resources in gene banks, on-farm conservation remains a neglected area, as acknowledged in the second FAO report on the State of Plant Genetic Resources for Food and Agriculture (FAO 2010). Uncomfortable observations made over two decades ago by Brush (1995)—that *ex situ* conservation may inadvertently preclude *in situ* efforts, and that "little is known about the actual crop populations in question and even less about the farming cultures that produce them"—still resonate.

The little known vegetable "mauka" is a perennial belonging to the Nyctaginaceae (four o'clock) family, characterized by its sprawling decumbent growth habit and abundant edible roots. Traditionally, mauka is cultivated between 2,500 and 3,500 meters above sea level (m a.s.l.) and has been observed in Ecuador, Peru, and Bolivia; an area that corresponds to one of the New World centers of plant domestication identified by Vavilov (Hawkes 1999). Alongside potatoes (*Solanum* spp.), it is one of the nine Andean root and tuber crops (ARTCs) recognized by the International Potato Center (CIP) for their nutritional and economic significance to local subsistence farmers (CIP 2019). Although considered an ancient crop, it was not until the 1960s—after its "discovery" by local agronomists Julio Rea and Jorge León in a remote community in northern Bolivia—that mauka became known to the scientific community (Rea and León 1965).

In 1989, mauka appeared in the landmark publication *Lost Crops of the Incas* as part of a host of Andean crops thought to have been overlooked as a result of centuries of cultural marginalization following the Spanish conquest, despite their potential for worldwide cultivation (National Research Council [NRC] 1989). Having remained invisible to the outside world for longer than most "lost" crops, mauka was portrayed by its authors as particularly obscure. Understood to be high yielding and nutritious, yet poorly studied and at risk of disappearance, they called for further research into its botanical characterization, agronomic potential, and geographic distribution. Furthermore, they highlighted the urgent need for the collection of genetic material. In the years that have followed, other ARTCs have emerged from the shadows to become foods of intentional prominence. For example, oca (*Oxalis tuberosa* Molina) is now sold by some specialist grocers in Europe, and maca (*Lepidium meyenii* Walp.)—which up until the 1980s was cultivated in an area in Peru no larger than 50 ha—has experienced "a meteoric rise from an overlooked botanical curiosity to internet notoriety" (Hermann and Bernet 2009). Mauka, on the other hand, remains an enigma.

Our study homes in on the scattering of fields and kitchens where this forgotten crop survives and—in some cases—thrives. Through ethnobotanical fieldwork carried out in Peru by Gendall in 2016, we aim to reconsider mauka's known geographical range and to better understand the crop from farmers' own perspectives—in terms of its local significance, traditional uses, and future potential. The study was underpinned by our motivation to understand and improve mauka's conservation potential, to which we sought an active and multi-angle approach. First, we responded to the need to conserve mauka *ex situ* by collecting germplasm in concert with the documentation of traditional knowledge—an integrated approach advocated by Nazarea (1998), which considers both biological and cultural strands. Second, recognizing that revaluing neglected crops can provide both income-generating opportunities for, and give visibility to, rural households—and that mobilizing them as such can support *in situ* conservation (Cohen et al. 1991; Padulosi et al. 2019)—we facilitated a pilot investigation into mauka's revaluation as a gastronomic ingredient. Working with the internationally renowned restaurant *Central*, based in Lima (Peru), we observed kitchen trials with mauka and facilitated a meeting between the restaurateurs and mauka farmers, exploring incentives to revitalize cultivation and ecological knowledge production.

Background

Wild *Mirabilis expansa* was first botanized by Ruíz and Pavón (1798) as part of an expedition led by the Spanish crown. Remarkably, another two centuries

passed before the plant became known to science in its cultivated form, when it was reported by Rea and León (1965) in Camacho Province, northern Bolivia. While *M. expansa* goes by many vernacular names, the local Camacho designation "mauka" has endured as that most widely adopted by the scientific community. For almost two decades following its discovery, mauka remained fugitive; known only to exist in northern Bolivia. However, during the early 1980s, it was Rea who again stumbled upon the crop, confirming its existence in the Ecuadorian highlands, where it is known as "miso" or "tazo." Following this revelation, Rea published basic ethnobotanical information about the crop, a call to action preventing its disappearance, and his hypothesis that it had made an important contribution to pre-Inca livelihoods (Rea 1982).

In 1984, Peruvian agronomist Juan Seminario found mauka in the Chota Province of Cajamarca, northern Peru, spurring exploration in that region. Within a few years, it had been cited across the departments of Cajamarca and La Libertad and in the Chachapoyas Province of Amazonas (all northern Peru) (Seminario 1988). In 1995, Mauro Vallenas observed mauka in Sandia Province, far-southern Peru, forwarding germplasm to the University of Cajamarca (UNC) where it was characterized as morphologically distinct from that of the northern provenance (Seminario and Valderrama 2012); although this accession was later lost during the severe 1997–1998 El Niño weather event. More recently—in relative proximity of Sandia and not far from the site of its original discovery—the persistence of mauka in the community of Chullín (northern Bolivia) was confirmed by Alvarez Mamani (2001).

Mauka is cultivated in mixed cropping systems by smallholder farmers. Production is thought to be almost exclusively for subsistence, with just a few recorded examples of mauka having been observed in the marketplace. Its culinary potential has been largely disregarded, even though nutritional studies have shown that mauka has higher levels of calcium, phosphorus, and protein than most other ARTCs (Seminario 2004). In fact, mauka's unusual profusion of calcium has led to the speculation that it could be used in the treatment of osteoporosis—an idea promoted by the widely read Peruvian agricultural magazine *Revista Agronoticias* (Anonymous 2015).

The scientific understanding of mauka and its agronomic potential has been enhanced by research carried out over several decades by Juan Seminario—most notably an ethnobotanical study (Seminario 2004) and numerous publications based on field experiments at the UNC, the majority of which are in Spanish. Recently, a report on the agronomy of mauka, which synthesizes both Seminario's work and findings from other existing studies, has been published by several authors of this study (Seminario et al. 2019). Based on a review of secondary sources and field trials with two varieties of mauka in Illinois (USA), Kritzer Van Zant has also published several papers on its ethnobotany and potential as a forage crop (Kritzer Van Zant 2016a, b; Kritzer Van Zant et al. 2018). However, when we embarked on fieldwork in 2016, there was evidently a need for up-to-date primary research on mauka and, most importantly, a consideration of local perspectives relating to it.

Field Methodology

Fieldwork areas were established following Seminario and Valderrama's (2012) recommendation to concentrate efforts in the departments of Ancash, Amazonas, Huánuco, and Puno—where little or no formal research on mauka had previously been carried out. However, we were warned that finding mauka in these understudied regions would be challenging, if not futile. Indeed, three decades prior to our study, Hermann and Heller (1997) wrote that the number of farmers still cultivating mauka might total a few thousand at best, predicting that if the trend of rural migration and crop abandonment continued, it could become extinct within one or two generations. Our sampling strategy was therefore to find and interview as many mauka producers as permitted by the constraints of time, resources, and logistics.

Five separate field trips of between 5 and 14 days were conducted over the period April–September 2016, allowing observation of the crop in various developmental stages, with GIS mapping used to record cultivation sites. Semistructured interviews were carried out with a total of 26 farming households found to be cultivating mauka, and stem cuttings were collected from the same number of sites. To increase the sample size, we also interviewed a second category of farmers—those who had previously cultivated or otherwise been familiar with mauka—which added a further 14 to the dataset. Drawing a distinction between the two, we refer to the former category as *active-memory* interviews and the latter as *latent memory* (summarized in Table 1; for precise

localities, see Appendix 1 [Electronic Supplementary Material, ESM]).

To verify their familiarity with the plant, those selected to take part in *latent-memory* interviews were required to describe several of its unique botanical characteristics: the small size and stickiness of the inflorescence and the naturally astringent taste of the root. With respect to local indigenous cultural and intellectual property rights, educated prior informed consent was obtained from each farmer who took part, following an explanation of the purpose of the project. The Instituto Nacional de Innovación Agraria (INIA) granted research permits for the collection of ethnobotanical information and crop genetic resources. Germplasm was forwarded to a research facility belonging to INIA in Cajamarca, which manages the *ex situ* conservation of ARTCs. Herbarium specimens representing 11 sites (nine cultivated and four wild examples) were contributed to local herbaria at the Universidad Agraria La Molina (MOL), Universidad Nacional Mayor San Marcos (USM), and CIP.

In the pilot experiment assessing mauka's gastronomic potential, we acted as both facilitators and participant observers. In July 2016, Gendall delivered 10 kg of mauka roots to *Central* in Lima, as requested by head chef Virgilio Martínez, purchased from two separate farmers in Ancash at PEN 7.5 per kilo (approx. USD 2.28 kg^{-1}). There we watched chefs experimenting with mauka in the kitchen and, as diners, sampled dishes made with it. Two months later, we facilitated a meeting with *Mater Initiativa*—the restaurant's research team—and one of the two suppliers who had sold mauka to them, at their farm in Ancash. To gain an understanding of the broader context, semistructured interviews were carried out with 20 key informants including local agronomists, representatives of Peruvian governmental organizations, and several European horticulturalists familiar with mauka.

Findings and Discussion

Geographical Range and Botanical Characterization

The map in Fig. 1 shows mauka cultivation sites recorded in Peru at various time periods. Sites recorded in Cajamarca, La Libertad, and Amazonas prior to 2015—by Seminario during multiple field trips starting in 1984 and by Franco et al. (1989)—have built an image of mauka's range in northern Peru. Meanwhile, Vallenas's (1995) observation of mauka in Puno has evidenced its presence in the south. Accordingly, the significant distance of separation between these two clusters—approximately 1,180 km—has led to the idea that mauka's distribution pattern is disjunct. Furthermore, since northern Peru is where the highest number of documented sites and the greatest diversity of vernacular names have been recorded, some scientists have hypothesized that it is the center of *M. expansa* domestication, proposing that long-distance dispersal occurred as a result of forced migration outwards from Cajamarca and the surrounding area to northern Ecuador and southern Peru/northern Bolivia, under Inca rule (NRC 1989).

During 2015, a handful of cultivation sites were recorded in Ancash by Prof. Saturnino Castillo from Colegio Simón Bolívar, Huaráz. Shortly after, during our 2016 fieldwork, a further 26 localities across Ancash, Huánuco, and Puno were registered. Later in 2017, two more were noted by Seminario in Cajamarca and Huánuco. Although the map still shows two distinct clusters, these more recent explorations reduce the distance between them to approximately 876 km, prompting us to reconsider the historical movement of the crop. Therefore, although the theory that northern Peru is the cradle of mauka domestication holds weight, we encourage researchers to consider other possibilities,

Table 1. The number of farmers which took part in the study, by region and interview type.

Regional department	*Active memory* Those still cultivating mauka	*Latent memory* Those previously cultivating or otherwise familiar with mauka
Ancash	11	4
Huánuco	13	5
Puno	2	2
Amazonas	0	3
Total	26	14

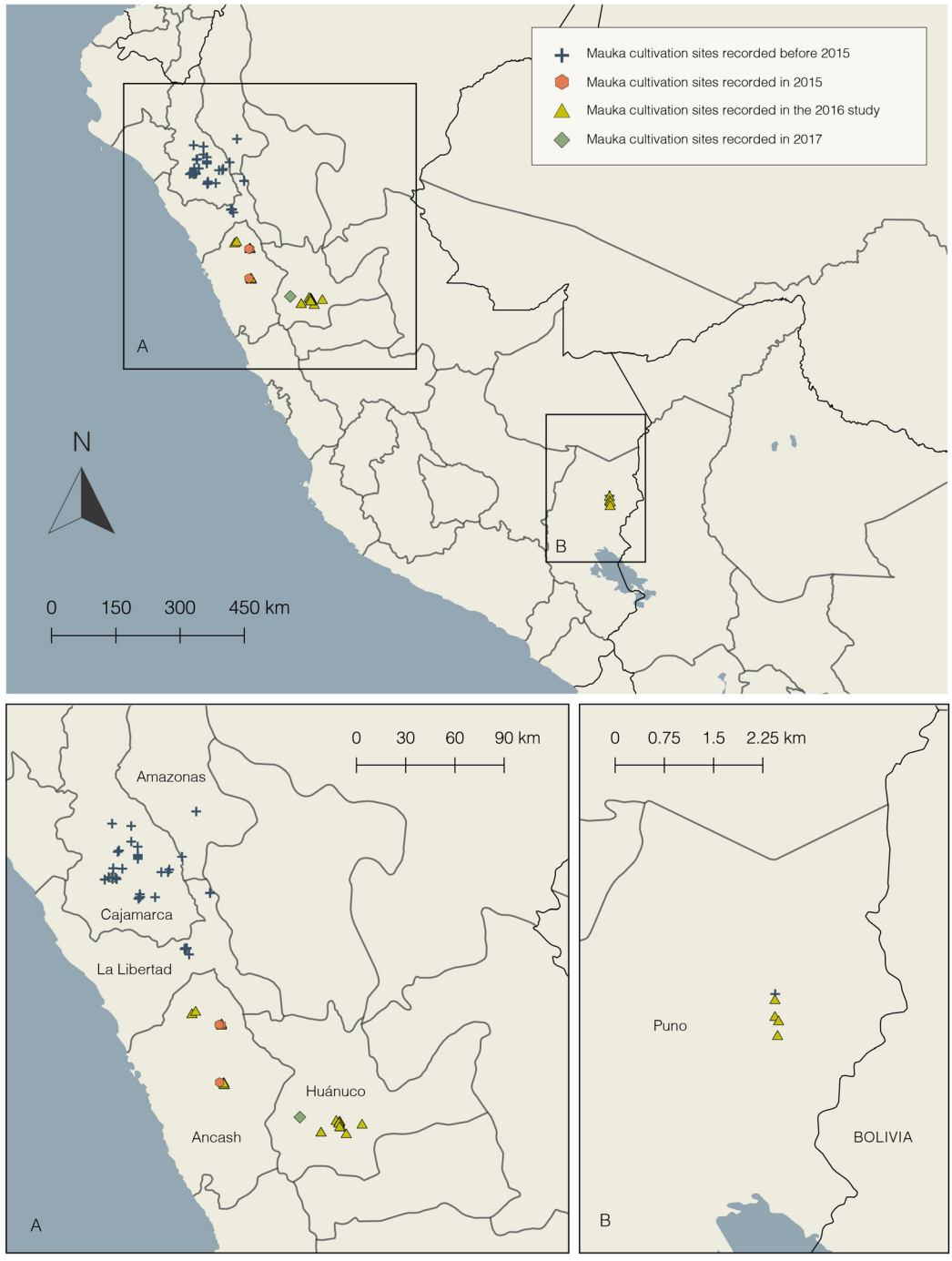

Fig. 1. Map showing mauka cultivation sites recorded during four time periods, illustrating how the known geographical range of the crop has widened in recent years.

namely, that it could have originated in southern Peru/northern Bolivia before moving northwards, or that domestication might have occurred independently in the north *and* in the south.

Taking this a step further, we question if mauka's geographical range is truly disjunct, or whether the pattern reflects the more recent disappearance of intermediate populations. According to our correspondence with several agronomists based in the region who are familiar with ARTCs, we think it is unlikely that mauka will be found in Cusco, although it might have occurred there historically. However, in our experience, wherever mauka was found, farmers tended to share accounts of friends or relatives cultivating it in neighboring communities. Consequently, we believe that the gap could be reduced further by extending explorations to the connecting departments of Junín, Huancavelica, Ayacucho, and Apurímac.

The altitudinal range for mauka cultivation sites was 2,769–3,369 m a.s.l., with the lowest point at San Pablo de Pillao (Huánuco) and the highest at Churubamba (Huánuco). Incorporating existing altitudinal data from other studies (Morillo Velastegui 1998 [Ecuador]; Seminario and Valderrama 2012 [Peru]; Alvarez Mamani 2001 [Bolivia]), the known range widens to 2,300–3,450 m a.s.l., with the maximum value corresponding to Chullín (Bolivia) and the minimum to Namora (Cajamarca).

Based on material conserved at the UNC, Seminario and Valderrama (2012) previously characterized five landraces (I–V). Four of these originate from the field, while the fifth is a cross between landraces I and II, which occurred *ex situ*. We found that the majority of cultivated mauka from the northern departments of Ancash and Huánuco was green-stemmed and white-flowered, corresponding to landrace II. In contrast, all plant material from the southern department of Puno exhibited reddish purple pigmentation, with several specimens corresponding to landrace IV—that which was collected by Vallenas in Sandia and then lost by the UNC 20 years prior as a result of the El Niño weather event. Also in Puno, we observed an undocumented variety with a vivid magenta subterranean stem cortex, exemplifying greater intraspecific diversity than previously known. Two distinct landraces described by Alvarez Mamani (2001)—both recorded in the same community in northern Bolivia (*yuraq mauk'a* and *kellu mauk'a*)—most likely reflect further diversity. As far as we know, this is the only recorded example of local farmers cultivating multiple mauka landraces at once.

Ex Situ Mauka Conservation

Of the 26 germplasm collections, 21 survived and are now being conserved by INIA in Cajamarca, more than doubling the number of mauka accessions held there (see Appendix 1, ESM, which indicates corresponding localities). This is now the most extensive *ex situ* collection, although the UNC is not far behind and historically has been more active in collecting and carrying out research specific to mauka. Increased germplasm diversity is now being safeguarded, with several enthusiastic nongovernmental actors playing an important role by conducting their own agronomic trials with mauka (an organic farm in Corongo and the Colegio Simón Bolívar in Huaráz, both in Ancash). However, material from Ecuador and southern Peru is drastically underrepresented, and there are no *ex situ* collections of mauka from Bolivia. Moreover, these are living collections and not immune to weather extremes, pests, and diseases, or the financial challenges of maintaining them in the long run.

Farmers' Perspectives on Mauka Cultivation Past and Present

Traditional mauka cultivation is thought to be strictly small scale. Plants are generally found in homegardens as opposed to *chacras* (fields) (Tapia et al. 1996) and at quantities rarely exceeding five individuals (Franco et al. 1997). However, our study found that almost three-quarters of farmers were cultivating mauka in *chacras*, not homegardens and—although the majority were cultivating between one and five plants—this was not always the case. Nearly one-quarter of the households were cultivating between six and 10 plants, four had between 16 and 20, one was cultivating 25, and another a total of 27.

Farmers reported a surprisingly high prevalence of mauka cultivation in their communities 20–50 years ago (the period roughly corresponding to the preceding generation of adult farmers). Although one-third said that the level of cultivation had been "quite low," 23% reported that it had been relatively common, 30% described the level of cultivation as being "quite high," and 15% said that the prevalence of mauka cultivation at that time had been "high" (Fig. 2). This contrasts with impressions of present-day cultivation that almost half of the farmers described as being "quite low," and a further 42% said was "at the point of

disappearance." In Amazonas, all households reported that the tradition of mauka cultivation had disappeared.

The question of just how prevalent mauka was historically remains open to debate. Throughout Seminario's approximately 30 years of fieldwork in Cajamarca and La Libertad, he generally observed farmers cultivating just a handful of mauka plants each, with a maximum of around 40 plants recorded on one occasion, leading to the conclusion that while more farmers might have cultivated it in the past, perhaps they never did so in large quantities. However, some accounts from our study contradict this, suggesting that mauka was indeed a larger-scale crop in regions further south. For example, in Ratacocha (Huánuco), one farmer recalled substantial levels of mauka cultivation:

> When we were children, kuyacsa [mauka] was planted in every chacra […]. Entire chacras, with maize and beans. All the neighbors had it. Before, because there was a lot of it, we used to collect it in sacks. We no longer harvest or eat it.

In Ancash, another informant explained that, up until a few years ago, mauka was being cultivated in high quantities in a *parcela común*—a common plot of land—by a group of neighbors in Chuncana, Palo Seco. Moreover, in Sandia (Puno), cultivation appears to have been particularly high, with one farmer explaining:

> I think at least a third of families should still have a few plants. We all used to have it before. About 40 years ago everyone had mauka, and there was a lot of it. Longer ago, there was even more. In one chacra you could find up to 200 plants—that's the quantity my grandmother used to cultivate.

These rich anecdotes hint toward the idea that mauka was indeed a significant crop for some Andean communities; however, a larger number of farmers across a wider geographical range would need to be interviewed to make a firmer overall assessment and explore the distinctions likely to occur between regions.

Cultural Significance and Local Nomenclature

Many vernacular names were heard during the study, some recorded previously and others for the first time (Table 2). *Mauka* remains the only denomination for cultivated *M. expansa* heard in southern Peru, and in Huánuco the plant is commonly known as *kuyacsa* (although on one occasion it was referred to as *superracacha* and on another as *ooshpica*). In northern Peru, where

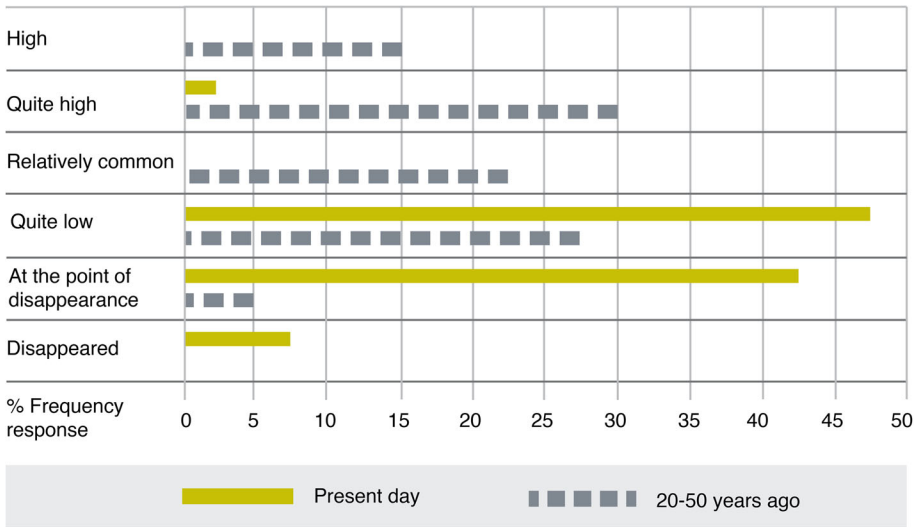

Fig. 2. Farmers' perceptions of the prevalence of mauka cultivation in their communities in the present day, compared with their perceptions of the period 20 to 50 years ago (across all study sites).

TABLE 2. VERNACULAR NAMES FOR MAUKA RECORDED DURING THIS STUDY (IN BOLD) COMBINED WITH THOSE FROM EXISTING STUDIES AND HERBARIUM SPECIMEN LABELS (NOTE: SPELLINGS ARE AN APPROXIMATION AS THESE ARE SPOKEN, NOT WRITTEN, DENOMINATIONS).

Region	Locality	Vernacular names
Ecuador	Pichincha; Cotopaxi	Miso, tazo
North Bolivia	Chullín (La Paz)	Mauka, yuraq mauk'a (white), kellu mauk'a (yellow), k'ita mauk'a (wild *M. expansa*)
South Peru	Sandia (Puno)	**Mauka**
	Chincheros (Cusco)	Moqo Moqo (wild *M. prostrata*)
North Peru	Cajamarca; La Libertad	Chago, chagos, chaco, achagu, yuca de jalca, arricón, cushpe, cushpenes, yuca Inca, camotillo, arracacha de toro, rábano, rabanito, pega pega, yuquilla, kashpa yuca
	Amazonas	**Shalca**, **shallca yuca**, **shaggchya rumo**
	Ancash	**Quishpi yuca**, **coshpi yuca**, **cospiyá**, **allja yuca**, **yuca de la sierra**, **pishpi yuca**, **ñatin jora** (wild *M. prostrata*)

mauka goes by many names, variations such as *quishpi yuca*, *pishpi yuca*, *coshpi yuca*, and *kashpa yuca* chime with one another. Indeed, it is remarkably similar in taste and appearance to the well-known staple "yuca" (*Manihot esculenta* Crantz, also known as cassava or manioc), native to tropical lowland South America. Interestingly, the literal translation of *yuca de jalca* and *allja yuca*—which denotes a yuca-like plant belonging to the *puna*, the ecoregion above 3,100 m a.s.l.—is somewhat a misnomer, since mauka occupies mid-range altitudes.

When asked why they cultivate mauka, the most common explanation was that it had been inherited from their parents, grandparents, or even from their ancestors. Some stated that cultivation was a conscious practice, necessary to prevent its disappearance, with one couple from Ancash (Fig. 3a) portraying mauka as an important relic: "Allja yuca [mauka] has always sustained our ancestors and us. It is like a memory or souvenir from them. The Inca used it as food, but now very few people cultivate it." However, the majority characterized mauka as merely a remnant from the previous generation, maintained out of habit. Most considered it a basic foodstuff with no historical or cultural significance, with some describing it as a weed.

WILD MAUKA

The only region where farmers identified wild mauka was Corongo (Ancash). Here one household referred to *M. prostrata* (Ruíz & Pav.) Heimerl as *ñatin jora*, meaning "liver herb" in the local Llajuash dialect. Present in abundance along the border of their *chacra*, they often harvest the foliage to use as pig feed. A second farmer explained that wild mauka was present in the area and associated with a particular larva. Wild specimens—including *M. expansa*, *M. prostrata*, *M. intercedens* Heimerl, and many unidentified *Mirabilis* species—were observed in four herbaria visited during the study (K, CUZ, MOL, and USM). These confirmed the historical presence of mauka's crop wild relatives in the Peruvian departments of Lima, Ancash, Huancavelica, Lambayeque, Junín, Arequipa, Moquegua, Cusco, and Puno. In Bolivia, Alvarez Mamani (2001) documented wild mauka referred to as *k'ita mauk'a*, encompassing what are thought to be several species.

TRADITIONAL CULTIVATION PRACTICES

September and August were most frequently mentioned for planting mauka, coinciding with the beginning of the wet season, while the drier months of July and August were those most commonly recommended for harvesting. However, farmers generally reported that mauka can be planted or harvested at any time of the year, providing it has matured. Other crops with more fixed cycles—such as maize, with which it was commonly found intercropped—often determine this. One informant in Ancash suggested that maize may shelter mauka from frost damage, to which its foliage is susceptible. Another informant from

Fig. 3. **a** Farmers with mauka crop in Corongo, Ancash. **b** Subterranean stems, used for clonal planting. **c** Mauka propagules exposed to the sun. **d** Mauka and oca "asoleando" (sweetening in the sun).

Huánuco recalled how mauka was most favorably cultivated in assortment with maize, beans, yacón (*Smallanthus sonchifolius* [Poepp. & Endl.] H. Robinson), and squash (*Cucurbita pepo* L.). However, several others warned that close intercropping compromised root production.

The plant is propagated clonally, by the division of the subterranean stems that thicken significantly as the plant reaches maturity (Fig. 3b). While aerial stems can also be used, they have a much lower survival rate. Farmers explained that production could be raised significantly in just one growth season, with one reporting that a single mauka plant could easily be split into 25 plantlets. Although planting is generally carried out directly after harvesting, two informants recommended exposing the propagules (cormoids) to the sun for a period of 1 to 2 weeks beforehand to speed up seedling and root development (Fig. 3c). One farmer in Puno said that, although he generally used stem cuttings, mauka propagation via seed was known to produce higher yields. Nevertheless, rather than planting mauka year after year, farmers often rely on its ability to self-proliferate, by dropping its botanical seed or self-planting its crawling stems. One farmer explained how mauka is "very easy to propagate. You can cultivate it, but it is also born from the botanical seed. Even if you abandon it, it continues to grow."

While mauka appears capable of fending for itself, farmers described interventions necessary for improving quality and yield. For example, several emphasized the importance of *aporque*, the process of hilling up soil around the base of the plant at several months into its growth cycle, to promote the development of the subterranean stem and train it to grow upright. Most farmers did not carry out weeding or irrigation specific to mauka but explained that it would be indirectly tended to in the upkeep of the *chacra* or homegarden. Mauka was frequently referred to as drought tolerant and hardy, and the vast majority (84%) of farmers reported that it did not succumb to pests or diseases. One farmer remarked that mauka is "the healthiest of all the plants we cultivate." Indeed, several biochemical studies have shown that ribosome-inactivating proteins synthesized from mauka's storage roots have an antimicrobial effect against root-rotting microorganisms (e.g., Vivanco and Flores 2000). Although immature plants are susceptible to herbivory,

mauka's aptitude for self-defense is further heightened by its sticky, insect-trapping inflorescences.

Informants agreed that yellowing foliage and sticky flowers signaled crop maturity, with just over half stating that the vegetative period for mauka is about 1 year. While the minimum time reported was 8 months, several argued that allowing mauka to mature beyond 1 year is beneficial because the roots continue to increase in size. One farmer reported that 2 years is optimum, and the largest root measured during the study (30 cm in length) came from a plant belonging to a 99-year-old informant from Sandia who recommended 21 months for maturity. In fact, we suppose that her plant was older than this, as it had a prominently suberized stem cortex—a cork-like external layer known to develop only in very mature mauka plants.

Mauka is usually harvested using a *pico* (pickaxe) or a *barreta* (pole) to dig carefully around and lift out the roots. As a subsistence crop, farmers generally said that mauka is harvested plant by plant, as opposed to all at once, as and when it is required for consumption. Several even said that portions are harvested without digging up the entire plant, so that it serves as a living larder, as described by one farmer from Corongo:

> The 'allja yuca' [mauka] was not something we tended to much. So each time my grandmother said: 'Now, what shall I cook? Will there not be roots? Have you not seen a mature one? Go and see if some are yellow.' We would go and look, but we did not pull them out entirely. We dug with sticks to find the biggest and most beautiful roots, and we left the rest, the thinner ones, without damaging the plants much; because they then continued to develop, for other opportunities. We used the plant as 'la salvavida de la olla' [the life-aid of the cooking pot].

Farmers generally described mauka as high yielding. Superlatives such as *grandazo* (huge), *enorme* (enormous), and *tremendos* (tremendous) were used—especially in *latent-memory* interviews—to describe the size of its roots. However, several complained that, while this may have been true in the past, mauka is now a low-yielding crop. "The roots come out really thin—two or three, no more" remarked one farmer. Another said that all crops—not just mauka—are poor-yielding nowadays. During *active-memory* interviews, several farmers who were keen to demonstrate the size of the root expressed disappointment when unearthing a smaller than anticipated harvest.

Traditional Culinary Use and Other Applications

Unprocessed mauka roots can irritate the inside of the mouth, due to their content of oxalate crystals. However, leaving harvested roots out in the sun (a process referred to as *asolear* [to sun]) can eliminate this effect and enhance their natural sweetness, although in Huánuco, the word *amortiguar* (to dilute/dull down) was heard several times in reference to this (Fig. 3d). Two-thirds of farmers recommended this practice and suggested doing so for an average of 5 days, with several drawing a comparison with oca tubers that are also traditionally processed this way. As one farmer explained: "If kuyacsa [mauka] is not exposed to the sun, it has no flavor. In that way, it is like oca. That's what gives it flavor. The flavor is excellent; it has a good kind of aroma. However, one-third said that they do not associate this practice with mauka. In Sandia, for example, one farmer said that mauka roots should be consumed fresh because sun exposure dries them out, making them less palatable. Meanwhile, another from the same village said that her grandmother had taught her to always *asolear* the roots, to maximize their natural sweetness. Notably, one household reported consuming mauka both *asoleado* and fresh, depending on the occasion.

Almost three-quarters of farmers said that the taste of mauka is "agreeable" and an additional 18% reported that it was "very agreeable," while just 8% of households described mauka as having a "disagreeable" taste. No correlation was found between impressions of taste and geography or distinct landraces. However, in Chullín, Alvarez Mamani (2001) documented that *yuraq mauk'a* roots are considered less bitter than those of *kellu mauk'a*, and it has been claimed that Ecuadorian mauka is less astringent than elsewhere (NRC 1989). Taste descriptions ranged from *dulce* (sweet), *rico* (delicious), and *bonito* (beautiful) through to *pica* (it stings/is itchy) and *insipido* (insipid). Varied impressions were also given of its texture, including *suave* (smooth), *duro* (hard), *pesado* (heavy), and *harinoso* (starchy). At least five farmers indicated that mauka is particularly filling, and provides the energy needed to sustain hard physical work, with one

remarking: "When eating allja yuca [mauka] we bear in mind that it is a nourishing plant and we feel we are eating something good. We feel full and do not get hungry until lunch time."

Taste and texture were often compared to that of potato (*Solanum tuberosum* L.), sweet potato (*Ipomoea batatas* (L.) Lam.), arracacha (*Arracacia xanthorrhiza* Bancr.), oca, and—most commonly—yuca. Mauka was frequently described as being identical to, or even as a variety of, yuca. However, others emphasized that mauka is unique in taste, such as one farmer from Corongo who recalled with surprising clarity from some 40 years prior:

> Its flavor was not like yuca and not like arracacha either. It was also different from sweet potato and oca which are very sweet. It did not have such an outstanding flavor, it was quite insipid, but somehow it was still tasty. Its texture was smooth.

In preparing mauka, farmers described either peeling and then cooking the roots (Fig. 4a) or cooking and then peeling them (usually by hand). Boiled mauka is typically eaten in place of bread or potatoes for breakfast or lunch, or as an accompaniment to *caldo* (broth) (Fig. 4c), *guiso*/*estofado* (stews) or *picante de cuy* (spicy guinea pig stew). In Sihuas, one farmer demonstrated boiling mauka before hand peeling and pan frying it with herbs and tinned tuna (Fig. 4d). Another explained how she once had made a sweet pancake with mashed mauka roots, while a number mentioned that it can be grated and incorporated into *mazamorra* (a traditional dessert).

At the Colegio Simón Bolívar, pupils have successfully processed a flour from the roots that can be used in baking and as a thickener. Several farmers said that mauka was sometimes cooked in a *pachamanca* or *huatia*—an earthen oven where food is buried and baked with hot stones. As one farmer from Huánuco recalled:

> My father used to leave it to mature for two years... But what amazing kuyacsa! [mauka]. He would say 'hey daughters, we are going to have kuyacsa for lunch.' So at half past ten we would bury the kuyacsa for this pachamanca; a roast. We used to have a lot of goats, so my mother would make goat's cheese and grind up ají [chili peppers – Capsicum L. sp.] and that is what we would eat with the kuyacsa.

One family in Vista Alegre, Huánuco (Fig. 5a), explained that mauka is essential for helping new mothers regain strength during the postnatal period, referring to the roots as a tonic. While it has been written that mauka leaves are traditionally eaten as salad, none of the farmers interviewed for this study were familiar with that practice. Instead, the family recommended the following:

> If your hair falls out after having children, which is often the case for new mothers, kuyacsa [mauka] and sweet potato leaves serve as vitamins for the hair. You boil them in a pot with their stems and bathe your hair in it. This is how my mother used to wash hers. You can also drink kuyacsa and sweet potato leaves as a tea, for the vitamins too. That is what our grandparents used to do. That is why they were so good at remembering things.

Existing studies state that mauka leaves are commonly used as animal forage or feed (Seminario 1988; Tapia et al. 1996), but despite all interviewees keeping animals, almost half were unaware of this practice. Some said that their livestock had consumed mauka when grazing—with several noting that mauka was preferred over other plants—but that they had never purposefully fed it to them. Just over 10% said that they fed both roots and leaves to livestock, and one participant from Amazonas recounted how his neighbor used to cook the roots and feed them to her pigs, emphasizing that they grew well.

Farmers' Perspectives on Mauka Decline

The prominent theme among farmers' explanations for mauka decline is its lack of market value. One farmer from Huánuco described how she had taken a sack of mauka to market the previous year but, because nobody knew what it was, she could not sell any. If mauka had a market value, they argued, they would be willing to reuptake or expand cultivation. Several farmers cited examples of other traditional crops such as maca, mashua, and quinoa (*Chenopodium quinoa* Wiulld.) that have undergone a renaissance in recent years, reasoning that mauka

Fig. 4. **a** Peeling mauka. **b** Washed mauka roots. **c** Boiled mauka with caldo. **d** Mauka sautéed with tuna and herbs.

could follow suit. The NRC (1989) explains that, around the time of the Spanish conquest, mauka and other traditional Andean crops synonymous with indigeneity were displaced by European species such as wheat, barley, and carrots, in a process referred to as "botanical colonialism." However, farmers attributed the much more recent decline in mauka cultivation to the dramatic modernization of food customs and agriculture over the past few decades. Farmers reported that, although potatoes were historically confined to a higher altitude, improved varieties that thrive at lower altitudes are now ubiquitous, replacing mauka and other traditional crops. As one farmer in Sihuas recalled,

Fig. 5. **a** Family in Vista Alegre with mauka. **b** Farmer from Sihuas with mauka plant.

> I remember when I was small, there were not so many potatoes here, so we ate what there was to eat. 'Pishpi yuca' [mauka], arracacha and yacón. That is what everyone here ate. Potatoes were growing in the *punas* which we used to get in exchange with the highland people for our maize or squash. Bit by bit, the potato arrived. Now we plant mostly potatoes, displacing the older crops. The youth of today are not interested in cultivating old crops. Maize, wheat and potatoes are all we grow here now. Before, it was one-hundred percent subsistence farming. Now we sell a portion of our potatoes, and with that, we buy rice and pasta. The customs that our grandparents had are almost forgotten.

Farmers also linked agricultural change to the lack of interest in traditional foods and a shift in taste toward processed foods, particularly by the younger generation. This has been described by Cantor et al. (2018) as "dietary delocalization"—i.e., the displacement of local with nonlocal food customs. One farmer from Sandia whose neighbor gifted her some mauka roots during an interview commented,

> I make 'mazamorra de maíz' [maize pudding] and my children say to me: 'What is this? How disgusting! It smells horrible!' Like all children nowadays, they do not know it. Now there is rice, pasta, sugar. We buy that, and we work less in the *chacra*, so they do not know about farming or traditional kinds of food. I will take this mauka home now and cook with it, but I bet my son is going to say to me "What is this?"

Urbanization, especially the outwards migration of the younger generation from rural areas, was offered as a further explanation. Due to the lack of able-bodied agricultural laborers, one older couple had recently abandoned not just mauka but most of their crops. As Brush (2004) explains, a key driver of diversity is adaptation by localized crop populations through isolation in differentiated landscapes. Communities with a history of mauka cultivation remain relatively isolated, with farmers in this study reporting an average journey time of 1 h and 40 min to their nearest market. However, the extension of roads linking villages with urban centers, which several indicated had occurred only in the last few decades, has dramatically increased the movement of people and goods both into and out of rural localities. The absence of roads up until this point goes some way toward explaining why many aspects of traditional agricultural life, including the cultivation of mauka, persisted in these farther-flung areas.

Some farmers ascribed mauka decline to climate change because of the damage wrought by long dry summers punctuated with sharp frosts, resulting in low-yielding or destroyed crops. Several others described the plant as undeserving of scarce resources or simply not worth cultivating due to its antiquated nature, long vegetative period, and increasing tendency to underproduce. Importantly, several connected the dwindling of interest in mauka to the loss of cultural memory, explaining that those who have given up cultivating the crop have forgotten the customs and knowledge needed to make best use of it. Though touched on by the minority, the recognition that these processes go hand in hand is significant.

Mauka in the New Andean Kitchen

Traditional Foods and Peruvian Gastronomy

The "Peruvian gastronomic revolution," which originated in the early 1990s, has elevated the profile of Peru's culinary heritage both locally and internationally (Lauer and Lauer 2006). Peruvian cuisine is typified as a melting pot of pre- and post-Columbian elements, combining traditional local ingredients with European, Asian, and other influences. The promotion of national cuisine by the Peruvian state, adopted as a strategy for social cohesion and economic development, has been a cornerstone of this phenomenon, whereby food is positioned as the common thread that weaves together an otherwise culturally diverse population (Matta 2016a). A recent opinion poll reported that culinary culture is considered a greater source of national pride than Machu Picchu (Organización Mundial del Turismo 2016).

Another key driver has been the work of a handful of Peruvian chefs, mostly trained in Europe, who have risen to global prominence. As Matta (2016b) explains, they have introduced indigenous products

previously seen as backward into the fine-dining sphere, by using top-end Western culinary techniques. On the one hand, this has improved the attitude of the urban elite toward indigenous culture and enticed traditional foods, such as arracacha, out of obscurity. However, a major critique suggests that the estheticization enacted by high-end chefs—as permitted by their privileged social position—glosses over indigeneity. Further, it has been argued that the promise of cosmopolitan multiculturalism upheld by the gastronomic revolution is in fact deleterious to cultural uniqueness (García 2013), equating to what Grey and Newman (2018) refer to as "culinary colonialism."

Notwithstanding these genuine concerns, we believe that the impetus of food provenancing in Peru could be mobilized to provide commercial incentives for continued mauka cultivation with positive implications. After all, mauka's lack of market value was the most common explanation given by farmers as to why it is in decline. Raising the prestige of marginalized crops and developing their marketability (Brush 1995), as well as responding to the demand for uniqueness in flavor or quality found only in certain heritage foods (Smale et al. 2004), are both relevant to the on-farm conservation of genetic resources. Furthermore, the potential for local empowerment does not necessarily have to be negated by the evolution in cultural meaning undergone through a revaluation of this nature.

Pilot Experiment with *Central*

Central is the flagship restaurant of Peruvian chef Virgilio Martínez, currently holding the title of the world's sixth best restaurant (The World's 50 Best 2018). The restaurant focuses on exploring and showcasing the biological and cultural diversity of the country. Based in Lima, it has established its own research body *Mater Initiativa*, which—through country-wide expeditions to meet with farmers, foragers, ecologists, and anthropologists—seeks to "discover" marginal native ingredients and draw inspiration from traditional food cultures. Martínez positions his approach as taking a step beyond the existing paradigm of the Peruvian gastronomic revolution to tackle cultural and environmental issues more discerningly.

Experimenting with mauka in the kitchen during lunch service, Martínez created a series of quick dishes that were served to Gendall and two representatives from CIP (Fig. 6a). These included thin mauka crisps layered with fresh Andean cheese and herbs (Fig. 6b), mauka in a hot ceviche-style broth (Fig. 6c), and fried mauka with avocado puree and borage flowers, served alongside the 17-course Mater Elevations tasting menu, where each dish represents a discreet altitudinal niche. The restaurant team was enthusiastic about mauka's taste potential and versatility, expressing an interest in learning more about its traditional uses. Representatives from *Mater Initiativa* were later taught planting, harvesting, and processing techniques by mauka suppliers in Ancash (Fig. 6d).

Since then, they have reiterated their interest in sourcing mauka for the menu and working to conserve it. With the unveiling of Martínez's new restaurant *Mil* in rural Cusco in 2018—which emphasizes collaboration with local farmers and embeddedness in the high-altitude landscape—his reputation and philosophy are growing. Several of *Mater Incitativa*'s social media posts have featured mauka and, more recently, Martínez's partner Pia León—who was awarded Best Latin American Female Chef in 2018—announced that she would be serving it in her new restaurant *Kjolle* (The World's 50 Best 2018). Nevertheless, sourcing mauka in the quantity and regularity required by these restaurants will be challenging, and whether they can elaborate mauka's substance and story from the field to the plate, without lessening its biocultural integrity, remains to be seen.

Conclusion

Though production is unmistakably small scale and diminishing, this study indicates that—until recent decades—mauka was not just a homegarden quirk; rather, it was a food of considerable importance for some Andean communities, with a wider geographical range than previously thought. Its usefulness as a hardy, low-maintenance, self-proliferating crop continues to be appreciated today. Regrettably, however, important reservoirs of cultural memory are drastically depleted. Specialist techniques, such as *aporque*, sweetening mauka roots in the sun and using its foliage as livestock feed are unknown to a significant proportion of farmers. It can be speculated that such practices that enhance the usefulness and enjoyability of mauka were once commonplace, and that their infrequency in the present day both stems from and spurs local disinterest in the crop.

Fig. 6. **a** Martínez experimenting with mauka. **b** Thin mauka crisps layered with fresh Andean cheese and herbs. **c** Mauka in a hot ceviche-style broth. **d** A farmer in Ancash teaches Malena from *Mater Initiativa* how to plant mauka.

Montenegro de Wit (2015) urges us to challenge the one-dimensional accounts of loss that dominate our view of agrobiodiversity, posing a question particularly relevant to our case: "What are the effects of loss narratives—that is; the upshots of saying species are vanishing?" The exaggerated loss narrative told so far by much of the existing literature, which perpetuates the false idea that mauka is near impossible to come by, most likely has been to the detriment of investment in research and conservation. Mauka is not lost. Rather, its story is one of *both* loss *and* persistence. However, in order to ensure its survival, gene banking and the documentation of traditional knowledge must be urgently extended to all understudied regions, particularly in Bolivia where no *ex situ* collections exist (FAO 2019).

Suggesting that the inclination exists, many farmers in this study explained that, if mauka had economic value, they would be keen to continue cultivating it. To this end, the current momentum toward the revival of traditional native foods in Peru should be harnessed. However, any initiative carrying this idea forwards should involve farmers and chefs as co-strategists, so that it can be shaped in a way that crystallizes local knowledge. Mauka's long vegetative period, its astringency before processing, and its rustic nonuniform roots should not be downplayed. However, rather than being conceived as obstacles, such qualities could be reinterpreted both as selling points and as anchors for cultural memory. With a foothold in both the traditional and the modern Andean kitchen, producers and chefs could work together to revalue mauka in a way that benefits the farmer, the restaurant, and the species itself.

Acknowledgments

Our deepest gratitude goes to the farmers who took part in the study, for their enormous hospitality and willingness to participate. Heartfelt thanks also to our local collaborators INIA, CIP (notably Ivan Manrique), Virgilio and Malena Martínez of *Central*, Carola and Eilif Leidulvstad, Doris Chalampuente-Flores, Saturnino Lucio Castillo León, Javier Martínez, José Roncagliolo, Milka Tello, Wilber Loza, and Jhonatan Chaparro. Likewise, scholarly and practical input from Mark Nesbitt, Owen Smith, Doris Chalampuente, Gaia Luziatelli, and Miriam Kritzer Van Zant have been invaluable to this research journey. Finally, we are

grateful for the comments from three anonymous reviewers.

Literature Cited

Alvarez Mamani, V. H. 2001. Manejo y Conservación in–situ de Mauk'a (*Mirabilis expansa*, R. y P.) Standley, Yacón (*Smallanthus sonchifolius*, H. Robinson) y Racacha (*Arracacia xanthorrhiza*, Bancroft) en la comunidad de Chullina, Prov. B. Saavedra—Dpto. La Paz. Ing. Agr. Thesis, Facultad de Agronomia, Universidad Mayor de San Andrés, La Paz, Bolivia.

Anonymous. 2015. Para tener huesos de acero: Mauka o chago. Revista Agronoticias 413:5.

Brush, S. 1995. In situ conservation of landraces in centers of crop diversity. Crop Science 35:346–354.

———. 2004. Farmers' bounty: Locating crop diversity in the contemporary world. New Haven, Connecticut: Yale University Press.

Cantor, C., I. Chan, and K. Baines. 2018. From the *Chacra* to the *Tienda*: Dietary delocalization in the Peruvian Andes. Food and Foodways 26(3): 198–222. https://doi.org/10.1080/07409710.2018.1490376.

CIP (International Potato Center). 2019. Andean root and tuber crops. https://cipotato.org/crops/roots–and–tubers/ (October 2018).

Cohen, J. I., J. B. Alcorn, and C. S. Potter. 1991. Utilization and conservation of genetic resources: International projects for sustainable agriculture. Economic Botany 45(2):190–199.

FAO. 2010. Second FAO report on the state of plant genetic resources for food and agriculture. http://www.fao.org/3/i1500e/i1500e00.htm (October 2018).

———. 2019. The state of the world's biodiversity for food and agriculture. In: FAO Commission on genetic resources for food and agriculture assessments, J. Bélanger and D. Pilling, eds. Rome. http://www.fao.org/3/CA3129EN/CA3129EN.pdf. (April 2019).

Franco, S., J. Rodríguez, and L. Machuca. 1989. Catálogo de colecciones de recursos fitogenéticos de la sierra norte del Perú 1985–1989. Cajamarca, Perú: INIAA, PRONARGEN.

Franco, S., J. Rodríguez, and J. Uceda Vejarano. 1997. Caracterizacion y evaluacion del germoplasma de chago (*Mirabilis expansa*) del INIA, en el valle de Cajamarca. Presented at the Congreso Internacional de Cultivos Andinos, Universidad Nacional de San Antonio Abad del Cusco, Cusco, Peru.

García, M. E. 2013. The taste of conquest: Colonialism, cosmopolitics, and the dark side of Peru's gastronomic boom. Journal of Latin American and Caribbean Anthropology 18(3):505–524. https://doi.org/10.1111/jlca.12044s.

Grey, S. and L. Newman. 2018. Beyond culinary colonialism: Indigenous food sovereignty, liberal multiculturalism, and the control of gastronomic capital. Agriculture and Human Values 35:717–730. https://doi.org/10.1007/s10460-018-9868-2.

Hawkes, J. G. 1999. The evidence for the extent of N. I. Vavilov's new world Andean centres of cultivated plant origins. Genetic Resources and Crop Evolution 46(2):163–168.

Hermann, M. and T. Bernet. 2009. The transition of maca from neglect to market prominence: Lessons for improving use strategies and market chains of minor crops. Agricultural Biodiversity and Livelihoods Discussion Papers 1. Rome: Bioversity International. https://www.bioversityinternational.org/fileadmin/_migrated/uploads/tx_news/The_transition_of_maca_from_neglect_to_market_prominence__nbsp_lessons_for_improving_use_strategies_and_market_chains_of_minor_crops_1318.pdf (November 2018).

Hermann, M. and J. Heller, eds. 1997. Andean roots and tubers: Ahipa, arracacha, maca and yacón. Promoting the conservation and use of underutilized and neglected crops. 21. Rome: Institute of Plant Genetics and Crop Plant Research, Gatersleben/ International Plant Genetic Resources Institute.

Kritzer Van Zant, M. 2016a. History of *Mirabilis expansa* (Ruiz and Pav.) Standl.; Growth and use in the Andes. Atlas Journal of Biology:236–248. https://doi.org/10.5147/ajb.2016.0138.

———. 2016b. Review of the economic and ethnobotany of the family Nyctaginaceae. Atlas Journal of Biology:249–266. https://doi.org/10.5147/ajb.2016.0139.

Kritzer Van Zant, M., K. Diesburg, and D. A. Lightfoot. 2018. *Mirabilis expansa* growth, yield, and quality traits: First US field trials for an ancient, endangered, Andean crop. Atlas Journal of Biology:511–574. https://doi.org/10.5147/ajb.v0i0.174.

Lauer, M. and V. Lauer. 2006. La revolución gastronómica Peruana. Lima: Universidad De San Martin De Porres, Escuela profesional de turismo y hoteleria.

Matta, R. 2016a. Food incursions into global heritage: Peruvian cuisine's slippery road to UNESCO. Social Anthropology 24(3):338–352. https://doi.org/10.1111/1469-8676.12300.

———. 2016b. Recipes for crossing boundaries: Peruvian fusion. In: Cooking technology transformations in culinary practice in Mexico and Latin America, ed., S. I. Ayora–Diaz, 139–152. London: Bloomsbury.

Montenegro de Wit, M. 2015. Are we losing diversity? Navigating ecological, political, and epistemic dimensions of agrobiodiversity conservation. Agriculture and Human Values 33:625–640. https://doi.org/10.1007/s10460-015-9642-7.

Morillo Velastegui, L. E. 1998. Analisis de polimorfismo en las colecciones de Jicama (*Polymnia sonchifolia* P & E) y Miso (*Mirabilis expansa* R & P) del Banco de Germoplasma del INIAP. Ing. Agr. Thesis Ponticia Universidad Catolica del Ecuador, Quito, Ecuador. http://repositorio.iniap.gob.ec/handle/41000/574 (October 2018).

Nazarea, V. 1998. Cultural memory and biodiversity. Tucson, Arizona: The University of Arizona Press.

NRC (National Research Council). 1989. Lost crops of the Incas: Little–known plants of the Andes with promise for worldwide cultivation. Washington D.C.: National Academy Press.

Organización Mundial del Turismo. 2016. Alianza entre turismo y cultura en el Perú—Modelos de colaboración entre turismo, cultura y comunidad. https://www.e-unwto.org/doi/pdf/10.18111/9789284417575 (October 2018).

Padulosi, S. 2012. A new international collaborative effort on traditional crops, climate change and on–farm conservation. In: On farm conservation of neglected and underutilized species: Status, trends and novel approaches to cope with climate change, Proceedings of an International Conference, Frankfurt, 14–16 June 2011. Rome: Bioversity International.

Padulosi, S., D. M. Cawthorn, G. Meldrum, R. Flore, A. Halloran, and F. Mattei. 2019. Leveraging neglected and underutilized plant, fungi, and animal species for more nutrition sensitive and sustainable food systems. In: Encyclopedia of Food Security and Sustainability, eds., P. Ferranti, E. M. Berry, and J. E. Anderson, 3:361–370. https://doi.org/10.1016/B978-0-08-100596-5.21552-7.

Rea, J. 1982. El Miso: Una contribución de la agricultura Pre–Inca de Ecuador y Bolivia. Desde el Surco 5:23–26.

Rea, J. and J. León. 1965. La Mauka (*Mirabilis expansa* Ruíz & Pavón), un aporte de la agricultura andina prehispánica de Bolivia. Anales Científicos 3:38–41.

Ruíz, H. and J. Pavón. 1798. Flora Peruviana, et Chilensis. Madrid: Typis Gabrielis de Sancha.

Seminario, J. 1988. El Chago o mauka, *Mirabilis expansa* R. y P. en Cajamarca, Memorias: VI Congreso Internacional Sobre Cultivos Andinos. Quito, Ecuador: INIAP, Estación Experimental Santa Catalina.

———. 2004. Aspectos etnobotánicos y productivos del chago, miso o mauka (*Mirabilis expansa* [Ruíz y Pavón] Standley). In: Raíces Andinas: Contribuciones al conocimiento y a la capacitación, Conservación y uso de la biodiversidad de raíces y tubérculos andinos: Una década de investigación para el desarollo (1993–2003), ed., J. Seminario, 367–376. Lima: Centro Internacional de la Papa (CIP).

Seminario, J. and M. A. Valderrama. 2012. Variabilidad morfológica y evaluación agronómica de maukas *Mirabilis expansa* (Ruiz & Pav.) Standl. del norte peruano. Revista Peruana de Biología 19:249–256. https://doi.org/10.15381/rpb.v19i3.1001.

Seminario, J., D. Chalampuente–Flores, H. Gendall and M. Sørensen. 2019. The agronomy of mauka (*Mirabilis expansa* [Ruíz & Pav.] Standl.)—A review. Journal of Plant Genetics and Crop Research 1(2):1–23.

Shepherd, C. 2017. Andean cultural affirmation and cultural integration in context: Reflections on indigenous knowledge for the *in situ* conservation of agrobiodiversity. In: Indigenous knowledge: Enhancing its contribution to

natural resources management, ed., P. Sillitoe. Wallingford, Oxfordshire: CAB International.

Smale, M., M. R. Bellon, D. Jarvis, and B. Sthapit. 2004. Economic concepts for designing policies to conserve crop genetic resources on farms. Genetic Resources and Crop Evolution 51: 121–135. https://doi.org/10.1023/B:GRES.0000020678.82581.76.

Tapia, C., R. Castillo, and N. Mazón. 1996. Catalogo de recursos geneticos de raíces y tubérculos Andinos en Ecuador. INIA, Quito. http://repositorio.iniap.gob.ec/bitstream/41000/2695/1/iniapscpm66.pdf (October 2018).

The World's 50 Best. 2018. The World's 50 Best Restaurants list 1–50. https://www.theworlds50best.com/# (October 2018).

Vallenas, M. 1995. Vigencia del cultivo de mauka (*Mirabilis expansa*) en Puno, Perú, Resúmenes del primer Congreso peruano de Cultivos Andinos "Oscar Blanco Galdós," 11–16 setiembre. Huamanga, Ayacucho.

Vivanco, J. M. and H. E. Flores. 2000. Biosynthesis of ribosome inactivating proteins from callus and cell suspension cultures from *Mirabilis expansa*. Plant Cell Reports 19(10):1033–1039. https://doi.org/10.1007/s002990000210.