

## Substitutes for seeds of *Vitellaria paradoxa*, *Parkia biglobosa* and *Adansonia digitata* used for nutrition by five major ethnic groups in Benin, West Africa

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Katja Heubach<sup>1,2\*</sup>, Katharina Schumann<sup>3</sup>, Karen Hahn<sup>2,3</sup>

<sup>1</sup> Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) GmbH, Postfach 5180, D-65726 Eschborn, Germany

<sup>2</sup> Biodiversity and Climate Research Centre (LOEWE BiK-F), Georg-Voigt-Straße 16-18, D-60325 Frankfurt/Main, Germany

<sup>3</sup> Institute of Ecology, Evolution and Diversity, Goethe-University, Max-von-Laue-Straße 13, D-60438 Frankfurt/Main, Germany

\* corresponding author. E-mail address: katja.heubach@giz.de; Tel.: + 49 6196 79-7288

**Summary:** Non-Timber Forest Products (NTFPs) make a major contribution to the livelihoods and diets of rural households in the savanna ecosystems of West Africa. However, land use change and climatic variability might affect their availability in the future. Based on a survey among 227 households in Northern Benin, we investigated local substitution patterns for the seeds of the three socio-economically most important NTFP-species in the region, *Vitellaria paradoxa*, *Adansonia digitata* and *Parkia biglobosa*, being major sources for protein, fat, and micronutrients in local daily diets. Our study compared substitution patterns between, firstly, three income groups, to assess whether a household's socio-economic status has an influence on the choice of surrogates (low cost vs. more costly options). Secondly, we compared substitution patterns between the five major ethnic groups in the study region (the Fulani, the Bariba, the Ditammarie, the Kabiyé and the Yom). The choice of substitutes differed significantly across income groups. However, the poorest households clearly show to be the most vulnerable: up to 30 % of the sampled households stated they would lack an adequate replacement for the NTFPs in question. Furthermore, ethnic affiliation showed to have a considerable impact on the preferred alternative products due to underlying cultural traditions of plant use. Subsequently, aiming at maintaining – and enhancing – the local supply of *V. paradoxa*, *P. biglobosa* and *A. digitata* in order to secure their contributions to local diets, local land use policy should have a particular focus on their ethnic-conditioned use and particularly the specific requirements of the poorest community members.

**Key words:** Livelihood, non-timber forest products, NTFPs, rural income, forest dependency, West Africa, savanna ecosystem, rural poor

### SUBSTITUT DES GRAINES DE *VITELLARIA PARADOXA*, *PARKIA BIGLOBOSA* ET *ADANSONIA DIGITATA* UTILISÉES POUR LA NUTRITION PAR CINQ GROUPES ETHNIQUES MAJEURS AU BÉNIN, AFRIQUE DE L'OUEST

**Résumé:** Les produits forestiers non ligneux (PFNL) apportent une contribution majeure aux besoins quotidiens et aux régimes alimentaires des ménages ruraux dans les écosystèmes des savanes d'Afrique de l'Ouest. Cependant, le changement de l'occupation du sol et la variabilité climatique pourraient affecter leur disponibilité dans l'avenir. Sur la base d'une enquête menée auprès de 227 ménages du nord du Bénin, nous avons étudié les modèles de substitution locale pour les produits alimentaires des trois espèces de PFNL socio-économiquement les plus importantes de la région, *Vitellaria paradoxa*, *Adansonia digitata* et *Parkia biglobosa*. Leurs graines sont une importante source de protéines, lipides et micronutriments. Notre étude a comparé les schémas de substitution entre, premièrement, trois groupes de revenu afin d'évaluer si le statut socio-économique des ménages aurait une influence sur le choix des substituts (coût faible par rapport aux options plus coûteuses). Deuxièmement, nous avons comparé les modes de substitution entre les cinq principaux groupes ethniques dans la région étudiée (Fulani, Bariba, Ditammarie, Kabiyé et Yom). Le choix des substituts différait considérablement d'un groupe de revenu à l'autre. Cependant, les ménages les plus pauvres sont clairement les plus vulnérables: jusqu'à 30% des ménages échantillonnés ont déclaré qu'ils n'auraient pas un remplaçant approprié pour les PFNL en question. De plus, l'appartenance ethnique s'est révélée avoir un impact considérable sur les produits alternatifs préférés en raison des traditions culturelles sous-jacentes de l'utilisation des plantes. Par la suite, dans le but de maintenir - et d'améliorer - l'approvisionnement local de *V. paradoxa*, *P. biglobosa* et *A. digitata* afin d'assurer leur contribution aux régimes alimentaires des ménages ruraux, la politique locale d'utilisation des terres devrait porter une attention particulière à leur utilisation, surtout aux besoins spécifiques des membres les plus pauvres de la communauté.

**Mots clés:** Ressources de base, produits forestiers non ligneux, PFNL, revenu rural, dépendance des forêts, Afrique de l'Ouest, savane, populations rurales pauvres

### UNTERSUCHUNG ZUR SUBSTITUIERUNG DER IN DER ERNÄHRUNG GENUTZTEN SAMEN VON *VITELLARIA PARADOXA*, *PARKIA BIGLOBOSA* UND *ADANSONIA DIGITATA* BEI FÜNF ETHNISCHEN GRUPPEN IN BENIN, WESTAFRIKA

**Zusammenfassung:** Essbare Wildpflanzen stellen wichtige Nahrungsergänzungen, zu einer ansonsten nährstoffarmen Ernährung ländlicher Nichtholz-Forstprodukte (non-timber forest products, NTFPs) leisten einen wesentlichen Beitrag zu den Lebensgrundlagen und der Ernährung ländlicher Haushalte in den Savannenökosystemen Westafrikas. Landnutzungsänderungen und klimatische Variabilität könnten ihre Verfügbarkeit in Zukunft jedoch beeinträchtigen. Basierend auf einer Befra-

gung von 227 Haushalten in Nord-Benin untersuchten wir die lokalen Substitutionsmuster für die in der Ernährung genutzten Samen der drei sozioökonomisch wichtigsten NTFP-Arten in der Region, *Vitellaria paradoxa*, *Adansonia digitata* und *Parkia biglobosa*, die wesentliche Quellen für essentielle Proteine, Fett und Mikronährstoffe sind. Unsere Studie verglich zunächst die Substitutionsmuster zwischen drei Einkommensgruppen, um festzustellen, ob der sozioökonomische Status der privaten Haushalte einen Einfluss auf die Wahl der Substitute haben würde (geringere versus höhere Kosten bei der Beschaffung dieser Substitute). Zweitens verglichen wir die Substitutionsmuster zwischen den fünf großen ethnischen Gruppen des Untersuchungsgebietes (Fulani, Bariba, Ditammarie, Kabiyé und Yom). Die Wahl der Substitute unterschied sich signifikant zwischen den drei Einkommensgruppen, wobei die ärmsten Haushalte die höchste Vulnerabilität aufweisen: Bis zu 30% der in die Stichprobe einbezogenen Haushalte gaben an, dass ihnen ein angemessener Ersatz für die betreffenden NTFP fehle. Darüber hinaus zeigte die ethnische Zugehörigkeit einen erheblichen Einfluss auf die bevorzugten Alternativprodukte, der auf die unterschiedlichen kulturellen Traditionen bei der Nutzung der NTFPs zurückzuführen ist. Mit Blick auf die Sicherung der Beiträge von *V. paradoxa*, *P. biglobosa* und *A. digitata* zur lokalen Ernährung bzw. deren Verbesserung, sollte lokale Landnutzungspolitik die ethnisch bedingten Unterschiede in der Nutzung der NTFPs sowie die besonderen Bedürfnisse der unteren Einkommensgruppen stärker berücksichtigen.

**Schlagworte:** Nicht-Holz-Waldprodukte, NTFPs, ländliche Einkommen, Wald als Lebensgrundlage, Westafrika, Savanne, ländliche Entwicklung

## 1 INTRODUCTION

Non-timber Forest Products (NTFPs), i.e. products from wild plant and animal species, are inherent to the social-cultural traditions and livelihoods of rural African communities (CAVENDISH 2000; LYKKE et al. 2004; SHACKLETON et al. 2008; KALABA et al.; 2013a). NTFPs comprise all biological matters except sawn timber but including small wooden poles and stick to be harvested without technological requirements from forests and woodlands (CIFOR, 2011). Fruits, leaves, barks and other vegetable structures, as well as animal products, make important contributions to people's daily diets (ANGELSEN et al., 2014; HEUBACH et al. 2011), are used as firewood (BELCHER 2003; CUNNINGHAM et al. 2002), medicine (e.g., NDAM & MARCELIN 2004; BUNDSCHUH et al. 2011) and construction material (HEUBACH et al. 2013), and play essential roles in indigenous belief systems (CAVENDISH 2002; ANGELSEN & WUNDER 2003; FOPPES & KETPHANH 2004; CIFOR 2015). NTFPs are crucial to the socio-economic viability of households in rural areas worldwide. In unfavorable situations, e.g. famine or financial shocks, they provide a safety-net by filling gaps in consumption or cash income (BABULO et al. 2009; KAMANGA et al. 2009; WORLD AGROFORESTRY CENTER 2013). Globally, 1.6 billion people are considered being highly forest dependent (World Bank 2004, 2008).

In rural sub-Saharan Africa, more than half of the population relies on food harvested from their direct environment (World Resources Institute 2005), next to locally grown crops). A growing body of case studies gives evidence for the particular contribution of NTFPs to the economies of households living in rural agroforestry systems, both in terms of subsistence and cash income. For example, in Malawi, total income shares from fruit tree products only accounted for 15 % of household income (KAMANGA et al. 2009), and in the Republic of Congo wild plant products contributed up to 10 % to local income (DE MERODE et al. 2004). Assessing a larger set of forest products (incl. wooden and selected animal products), a study in Ethiopia found NTFPs to make up 27 % (BABULO et al. 2009), and one in Zimbabwe (including non-renewable NTFPs) even 35 % of rural household income (CAVENDISH 2000). Furthermore, a recent study in Northern Benin revealed wild plants to constitute on average 39 % of household cash and subsistence income (HEUBACH et al. 2011). In most of the studies NTFPs are characterized by open or semi-open access and

their collection does not require special technical equipment or financial means, thus, representing highly beneficial sources for livelihoods particularly for the rural poor (ANGELSEN & WUNDER 2003; VEDEL et al. 2007).

The variety of used species thereby is enormous. Particularly plant species are fundamental ingredients in daily consumption, important for construction and energy supply, and essential for medical treatment – mostly with multiple uses. For example, in the study area located in the south Sudanian zone of Benin more than 90 woody species are locally used, often for multiple uses, such as traditional medicine (61 % of the 90 woody species are used for that), dental care (49 % of the 90 species), firewood (41 % of the 90 species), construction (39 % of the 90 species), and wild foods (32 % of the 90 species) (HEUBACH et al. 2013). Likewise, amongst others, VODOUHÉ (2009) identified more than 70 plant species used daily by people living adjacent to the Pendjari National Park in Northern Benin, and LYKKE et al. (2004) identified 56 woody multi-use species highly valued by rural communities in the Sahel area of Burkina Faso.

However, use preferences for species might differ much within the studied communities. Based on their traditional knowledge and cultural backgrounds, specific social groups show differences in the collection and use of a specific set of plants. According to KEPE (2008) social differentiation is a key factor determining resource use in forest-based communities due to social affiliations to certain groups or networks (e.g., ethnic groups, user groups) and individual characteristics. In this context, recent studies in Benin and Burkina Faso shed light on the role ethnic affiliation plays with regard to plant use. In addition to individual household characteristics, such as e.g. age, gender, location, and access to farmland, ethnicity appeared to be highly influencing use values for woody plant species (CALUWÉ et al. 2009; FANDOHAN et al. 2010; SCHUMANN 2011; GOUWAKINNOU et al. 2011; HEUBACH et al. 2013).

Recently, there is growing concern that the occurrence of NTFP-providing plant species has been continuously negatively impacted by land use change, e.g. through the ongoing conversion of savanna areas into cultivated land (BRINK & EVA 2009), introduction of alien species (SHACKLETON et al. 2007), agricultural intensification (WITTIG et al. 2007), amongst others. Moreover, predicted climatic changes are likely to change future occurrences of plant species (IPCC 2007), including in our study region (WITTIG et

al. 2007). With regard to the three socio-economically most important woody species in Northern Benin – *Vitellaria paradoxa*, *Parkia biglobosa* and *Adansonia digitata* (VODOUHÉ et al. 2009; FANDOHAN et al. 2010; HEUBACH et al. 2013) – HEUBES et al. (2012) predicted a severe decrease in their occurrence in 2050 due to climate and land use change. Thus, it is of interest to assess whether and which alternatives rural communities might draw on to compensate current and possible future outage of those NTFPs they use largely for their daily consumption.

The study at hand investigated the general, current substitution patterns of households in case of temporary shortages for the three socio-economically most important woody species in the region (and in other areas of the Sudanian zone: see e.g. LESSMEISTER et al. 2015) *Vitellaria paradoxa*, *Parkia biglobosa*, and *Adansonia digitata* (VODOUHÉ et al. 2009; FANDOHAN et al. 2010; HEUBACH et al. 2013). Short-term NTFP shortage might be caused by inter-annual variations in NTFP availabilities, low rainfall and/or depleted stocks before the next harvest season. We explored current substitution patterns among the five major ethnic groups (the Fulani, the Ditammarie, the Kabiyé, the Bariba, and the Yom) in two villages in Northern Benin.

While *V. paradoxa* seeds are a key source for fat (MARANZ et al. 2004), *P. biglobosa* and *A. digitata* seeds provide valuable protein (TEKLEHAIMANOT 2004). Protein contents of the fermented *P. biglobosa* seeds even can exceed that of meat (KRONBORG et al. 2014). Besides, all of them add essential vitamins (TEKLEHAIMANOT 2004) to local diets. Being still available in the dry season (fruits of *P. biglobosa* and *A. digitata*), when fields are already harvested, and being suitable for mid-term storage, these species' seeds are excellent to overcome times of seasonal or financial shortcomings (SCHRECKENBERG et al. 2006; ARNOLD et al. 2011).

Potential sources for substitutes for these three species' seeds may be parts of other wild NTFP-providing species found in the adjacent savanna area, or of cultivated or purchased plants, animal products, or other marketed natural or manufactured goods. The choice of the replacement might, firstly, depend on their socio-economic status, i.e. their financial means allowing for more or less costly options. Secondly, as elaborated on above, ethnicity might play a major role in choosing substitutes, since ethnic affiliation comes along with particular knowledge on and traditions of plant and other product use. Thirdly, the choice of the substitute might also account for its potential to adequately complement for the nutritional values of the replaced NTFP.

Our study, thus, identifies households' current choice of substitutes for seeds of *V. paradoxa*, *P. biglobosa* and *A. digitata*, comparing i) three income groups, and ii) five ethnic groups. Additionally, we reflect on whether the substitutes meet nutritional values equaling those of the investigated NTFPs (based on existing figures from the literature), and draft options for adaptive measures to possible changes in NTFP supply.

## 2 STUDY CONTEXT

### 2.1 Characteristics of the study area

#### 2.1.1 Socio-economic setting of studied villages

We conducted our study in two villages in Northern Benin, Papatia and Chabi-Couma (30 km apart), in the Department of Atakora (Fig. 1) approximately 35 km from the northern economic urban center Natitingou. In 2008, of the Department population 62.3 % lived in rural areas and 70.3 % were considered poor.

We considered two villages to obtain a replication. Thus, our selection was based on the similarity of the two villages in terms of their socio-economic profile. Both are endowed with piped water, an own small local market, and a primary school. They are located in a similar distance from the urban center and the main road, i.e. have similar access to urban facilities and products. Both have only rudimentary access to electricity, and households' energy demands are primarily met by firewood collected in the adjacent savanna areas. Major ethnic groups located in the area are spread evenly in both villages.

Residents of these villages are mainly engaged in rain-fed crop production in agroforestry systems, small livestock husbandry and NTFP collection in the adjacent savanna areas. Off-farm income (e.g. local trading, tailor, motorbike taxi driver, employment in administrative and educational activities) is very rare. The importance of NTFP collection was conformed and underlined by SIEGLSTETTER et al. (2011), who found that 96 % of the 129 woody species existing in a neighbouring area were used.

#### 2.1.2 Biophysical environment

Belonging to the southern Sudanian zone with tropical climate and a rainy season from May to November, the savanna ecosystems in the study region are covered by tree and shrub savanna (MAYAUX & BARTHOLOMÉ 2003). As a result of the traditional small holder system of slash-and-burn agriculture in shifting cultivation, the agroforestry parklands show a pattern of old and young fields and fallows with selected multi-use trees spared from chopping.

#### 2.1.3 Ethnic groups

The five major ethnicities domiciled in the studied villages are the four tiller societies Bariba (autochthon, i.e. the original settlers in the region), Ditammarie, Kabiyé (both migrated from Togo) and Yom (originally from the Department of Bassila, south of the study area), as well as the pastoralist Fulani (from Kouandé, east of the Atakora chain) who settled in the region due to severe drought events (DE BRUIJN & DIJK 1994; BOLWIG & PAARUP-LAURSEN 1999). All ethnic groups are similar in terms of household size, age and education of head, with insignificant differences with regard to total household income and distribution into income groups (Table 1) (HEUBACH et al. 2011). Access to the savanna areas is traditionally semi-open. While within the village area particular sectors for harvesting NTFPs are exclusively assigned to the different local ethnic groups, access to

**Table 1: Comparison of socio-economic characteristics of investigated ethnic groups in Papatia and Chabi-Couma (N = 227 households; modified after HEUBACH et al., 2011). / Comparaison des caractéristiques socio-économiques des groupes ethniques étudiés à Papatia et Chabi-Couma (N = 227 ménages, modifiés après HEUBACH et al. 2011).**

N = 227	Bariba	Ditammarie	Kabiyé	Yom	Fulani
Main employment: tiller (%)	98	96	100	100	93
Main employment: livestock breeder (%)	-	-	-	-	5
Total household income (in Euro, per aeu* and year)	731	694	644	690	704
Very low income group (%)	28	35	28	39	37
Medium income group (%)	43	29	30	34	33
Above medium income group (%)	28	35	42	27	30

\*aeu = adult equivalent units (DEATON, 1982), i.e. mean income displays the adjusted income per person in the respective household

savanna resources beyond village level is unrestricted. Harvest of trees on farmland remains restricted to the farmland owners. Migrants who have borrowed land don't have rights to the products of the trees on these lands.

### 2.2 Investigated NTFP species

The selection of the NTFP-providing species to study here is based on the findings of HEUBACH et al. (2013) who found *V. paradoxa*, *P. biglobosa* and *A. digitata* to be the three woody species valued the most by rural communities in the region. They contribute to daily dietary needs in terms of fat, protein, and vitamins contained in their seeds, and present a large share to total household income (Table 2).

## 3 METHODS

### 3.1 Study design, data collection and data analysis

The data used in this analysis is part of a household survey on NTFP collection, use and socio-economic characteristics that was conducted with 227 randomly selected households in two villages (Chabi-Couma and Papatia) in Northern Benin, West Africa in 2009. The households were stratified according to their ethnic affiliation to one of the five major ethnic groups in the region, i.e. the Bariba, the Kabiyé, the Fulani, the Ditammarie and the Yom (45, 45, 45, 46, and 46 interviews, respectively).

Being the main collectors of NTFPs, women were asked to report substitutes used in diets when seeds of *Vitellaria paradoxa*, *Parkia biglobosa* and *Adansonia digitata* are not available due to temporal and/or seasonal shortage, e.g. when stocks are depleted before the next harvest. We did not

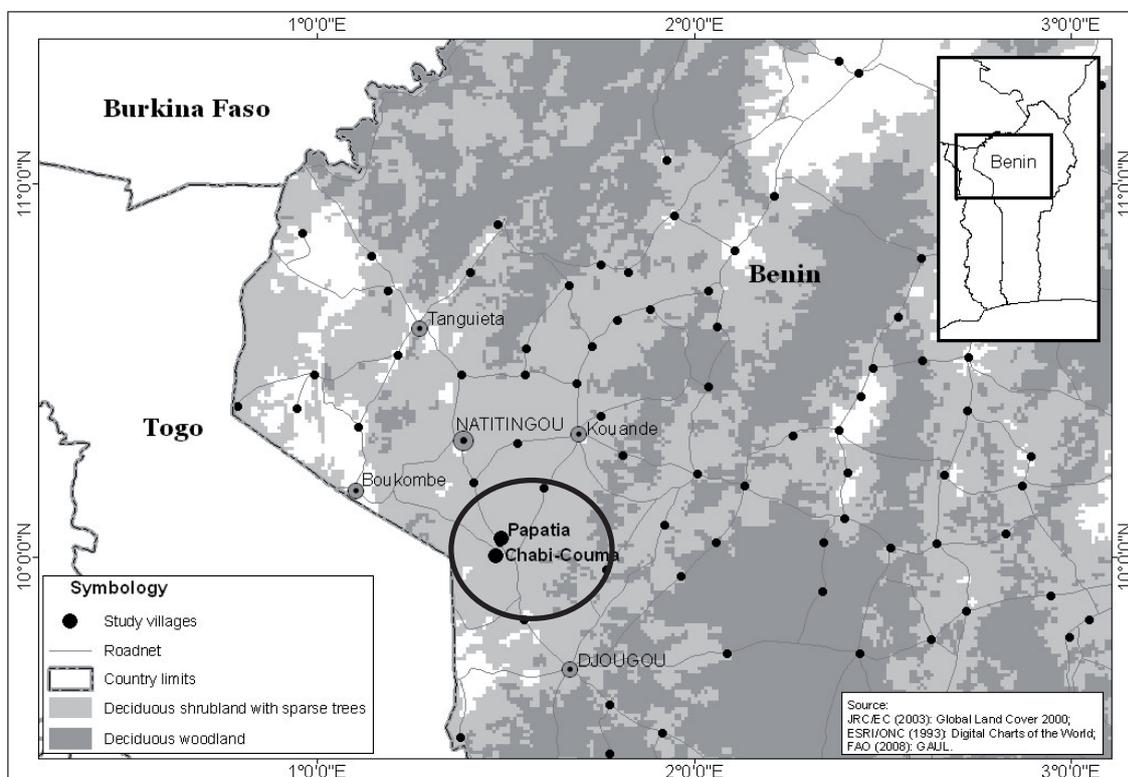


Fig. 1 : Map of the study area (Department of Atakora) with the two studied villages Papatia and Chabi-Couma. Large black dots (labelled) represent the two study villages; other smaller black dots (unlabelled) are displayed in order to represent the density of villages located within the savannah ecosystem. / Carte de la zone d'étude (Département d'Atakora) avec les deux villages étudiés Papatia et Chabi-Couma. De grands points noirs (étiquetés) représentent les deux villages étudiés; d'autres points plus petits (non étiquetés) sont affichés pour montrer la densité des villages situés dans l'écosystème de la savane.

**Table 2: Contributions by the three target species *Vitellaria paradoxa*, *Parkia biglobosa* and *Adansonia digitata* to local dietary needs, and related consumption and market patterns. / Contributions des trois espèces cibles *Vitellaria paradoxa*, *Parkia biglobosa* et *Adansonia digitata* aux besoins alimentaires locaux, ainsi que des modèles de consommation et de commerce respectifs.**

Species	Product and contribution to local diet	Consumption and market pattern
<i>Vitellaria paradoxa</i> (subspecies <i>paradoxa</i> , Shea Tree, local French name: Karité)	Shea nuts (kernels): contain up to 50 % fatty acids (TEKLEHAIMANOT 2004); processed into shea butter ('beurre du Karité') used as cooking oil and for skin care  Fruit pulp: excellent source of protein, calcium and sugar (MARANZ et al. 2004)	Average annual consumption of Shea butter in sub-Saharan countries ranges between 7.3 up to 10 kg per person (BOFFA 1999; DAH-DOVOVON 2006)  In 2009, the average share of income from <i>V. paradoxa</i> in total household income in the study area was 13 %, and 89 % of collected shea nuts were sold on local markets (HEUBACH et al. 2013)
<i>Parkia biglobosa</i> (African Locust Bean Tree or Néré)	Seeds: protein-rich with multiple essential amino acids (NORDEIDE et al. 1996); fermented and processed as local ingredient in sauces ('moutarde'); protein content is equal to or even higher than that of various kinds of meat (KRONBORG et al. 2014)  Seeds: also rich in fat (TEKLEHAIMANOT 2004)	Highly valued as staple food throughout West Africa (MERTZ et al., 2001)  In 2009, the average share of income from <i>P. biglobosa</i> in total household income in the study area was 10 %, and 88 % of collected seeds were sold on local markets (HEUBACH et al. 2013)
<i>Adansonia digitata</i> (African Baobab)	Seeds: rich in protein and fat (DE CALUWÉ et al. 2009); roasted seeds used as ingredient in sauces and as snack food; also as alternative to coffee; by pounding or boiling, the seed's oil can be extracted	In 2009, the average share of income from <i>A. digitata</i> in total household income in the study area was 2 %, and 73 % of collected seeds were sold on local markets (HEUBACH et al. 2013)

ask about changes in the availability of the three NTFPs or whether their reliance on them had increased.

On basis of the income data collected through the questionnaire, we calculated total household income. In accordance with CAVENDISH (2002), we defined a household's total income as the sum of cash income generated from various activities (e.g. crop and livestock production, collection of wild foods, small-scale activities) and the monetary equivalent of a household's subsistence use of the output of these activities. Total household income is accounted on annual basis. It reflects the net income generated by the population sample under investigation, i.e. the total value of output deducted by the total value of input (e.g. fertilizer for agricultural production, veterinary supplies) during the accounted period. Note that net income includes own-labor costs due to absent or thin labor markets in rural African settlements. To calculate income, we used means of local market prices (observed monthly at the two markets of Papatia and Chabi-Couma during the study period) and households' own-reported revenues from selling their products (in local units of measure – 'aguwe'). Both market prices and own-reported revenues were found to be strongly consistent for both agricultural and woodland products. In order to account for the varying compositions (number and sex of adults and children) of the studied households, we applied a combination of the OECD-modified equivalence scale due to type of household member (HAGENAARS et al. 1994) and used an economy-of-scale coefficient resulting in household size as the determinant of needs suggested by DEATON (1982). The adjusted income (all income sources) then equals income per adult equivalent units (aeu).

In order to compare NTFP substitution between income groups, we split the sample into income terciles: "very low income group" (N = 73), "medium income group" (N = 73) and "above medium income group" (N = 72). Mean annual total income per aeu (adult equivalent unit, i.e. adjusted income, according to DEATON (1982)), between income groups was significantly different (406 €, 669 €, and 1017 €, respectively; ANOVA  $p < 0.001$ ).

The substitutes reported in the interviews were grouped into three categories reflecting their origin: i) product of a culti-

vated/purchased plant, ii) product of other wild plant species, and iii) purchased animal or other product. Chi-square test was used to compare the counts of the three categories between income groups, ethnicities and villages. Chi-square tests were performed using IBM SPSS Statistics 22 (IBM 2013).

## 4 RESULTS

### 4.1 Substitutes for seeds of *Vitellaria paradoxa*, *Parkia biglobosa* and *Adansonia digitata*

Table 3 shows the results of the survey on NTFP substitutes. Asked for possibilities to substitute the seeds of *V. paradoxa*, women reported three possibilities, of which two are cultivated/purchased plants. More than half of the respondents declared that shea butter could be replaced by palm oil derived from the palm tree *Elaeis guineensis*, and one third mentioned to preferably substitute it by peanut oil. Only a negligible proportion of respondents mentioned to replace *V. paradoxa* seeds by butter from cow milk.

For *P. biglobosa* seeds, in total 12 substitutes were reported. They comprise eight products from cultivated/purchased plants (in decreasing importance: peanuts, chilies, onions, sesame, beans, *Blighia sapida*, soybeans), three purchased animal/ other products (in decreasing importance: fish, MAGGI cubes – product by Nestlé, salt), and one alternative wild plant species (*Ceiba pentandra*). The most quoted products were fish, MAGGI cubes (food flavoring product by Nestlé, main ingredient: salt, frequently used), peanut, and chilies.

The seeds of *A. digitata* can be substituted by five cultivated/purchased plants (in decreasing importance: sesame, peanuts, *B. sapida*, lady's fingers, tomato and two other wild plant species (*Vitex doniana*, *Parinari curatellifolia*). However, only three cultivated plants - sesame, peanut, and the seeds of *B. sapida* - were frequently quoted, while the other products were mentioned by very few respondents.

In general, cultivated/purchased plants were the predominant cited substitute category for all three studied species.

**Table 3: Substitutes for seeds of *Vitellaria paradoxa*, *Parkia biglobosa*, and *Adansonia digitata*. The assignment of each substitute to one of the three categories is also presented. / Substituts aux graines de *Vitellaria paradoxa*, *Parkia biglobosa* et *Adansonia digitata*. Le classement de chaque substitut dans une des trois catégories est également présenté.**

Substitute	Plant part	% of respondents	Product of a cultivated or purchased plant species	Product of a wild plant species	Purchased animal or other products
<b><i>Vitellaria paradoxa</i></b>					
Oil of <i>Elaeis guineensis</i>	fruits	57.9	x		
Oil of <i>Arachis hypogaea</i> (peanut)	fruits	29.8	x		
Butter made from cow milk		0.4			x
no substitutes		11.8			
<b><i>Parkia biglobosa</i></b>					
Fish, smoked		28.1			x
MAGGI cubes (Nestlé)		20.8			x
<i>Arachis hypogaea</i> (peanut)	seeds	13.9	x		
<i>Capsicum</i> spec. (chilies)	fruits	4.8	x		
<i>Ceiba pentandra</i>	seeds	3.5		x	
<i>Allium cepa</i> (onion)	bulb (dried)	3.0	x		
<i>Sesamum indica</i> (sesame)	seeds	2.6	x		
Salt		1.7			x
<i>Phaseolus vulgaris</i> (beans)	seeds (dried)	1.7	x		
<i>Blighia sapida</i>	seeds (aril)	1.3	x		
<i>Glycine max</i> (soybeans)	seeds	0.9	x		
<i>Hibiscus sabdariffa</i>	Seeds (fermented)	0.9	x		
no substitutes		16.5			
<b><i>Adansonia digitata</i></b>					
<i>Sesamum indica</i> (sesame)	seeds	41.0	x		
<i>Arachis hypogaea</i> (peanut)	seeds	15.4	x		
<i>Blighia sapida</i>	seeds (aril)	14.1	x		
<i>Abelmoschus esculentus</i> (lady's fingers)	seeds	1.3	x		
<i>Vitex doniana</i>	leaves	0.9		x	
<i>Lycopersicon esculentum</i> (tomato)	fruits, powder	0.4	x		
<i>Parinari curatellifolia</i>	seeds	0.4		x	
no substitutes		26.4			

For *P. biglobosa* and *V. paradoxa* seeds, animal and other products were the second most important category of substitutes, while for *A. digitata* seeds of other wild plant species were the second most frequently cited surrogates.

Peanuts were reported as a substitute for the seeds of all three studied species. In addition, the seeds of sesame and *B. sapida* were likewise mentioned as substitutes for the seeds of *A. digitata* and *P. biglobosa*.

Substitutes for seeds of *P. biglobosa* (12 substitutes) are nearly twice as many as for *A. digitata* (7 substitutes), and even four times higher than for *V. paradoxa* (3 substitutes). Furthermore, almost 30 % of respondents stated that they have no substitution for the seeds of *A. digitata*, and 10-20 % of respondents lack replacements for the seeds of *P. biglobosa* and *V. paradoxa*. Interestingly, the three studied NTFP species were not mentioned as substitutes for each other.

#### 4.2 Differences in substitution patterns between income groups

For all income groups, products from cultivated/purchased plants account for the primary source for substitution (63.6 % to 76.5 %), followed by animal/ other products (17.6 %

to 18.8 %) and other wild plant species (5.9 % to 18.2 %). Whilst accounting for a minor share in substitution generally, these alternative local plant species, however, are of high importance to the very low (18.2 %) and medium (12.5 %) income groups.

For *P. biglobosa* and *A. digitata*, the choice of substitutes differed significantly between income groups ( $\chi^2=19.8$ ,  $p < 0.01$ ;  $\chi^2=15.4$ ,  $p < 0.01$  respectively), while it did not differ significantly for *V. paradoxa* ( $\chi^2=4.38$ ,  $p > 0.05$ ) (Fig. 2).

Furthermore, a higher proportion of the poorer households (= very low income) reported to have no substitutes for the three NTFP species compared to the less poor households (= medium income and above medium income). For *V. paradoxa* seeds, 20 % of the poorest households, and 10 % of the less poor, lack appropriate substitutes. Above all, wild and, thus, free alternatives were not mentioned.

For *P. biglobosa*, even 30 % of the poorest households lack a proper substitution, compared to 10-15% of the less poor households (= medium income and above medium income). Less poor households preferably replace the raw material for moutarde with fish, being the more expensive alternative, while poorer households use the cheaper manufacture produce MAGGI cubes.

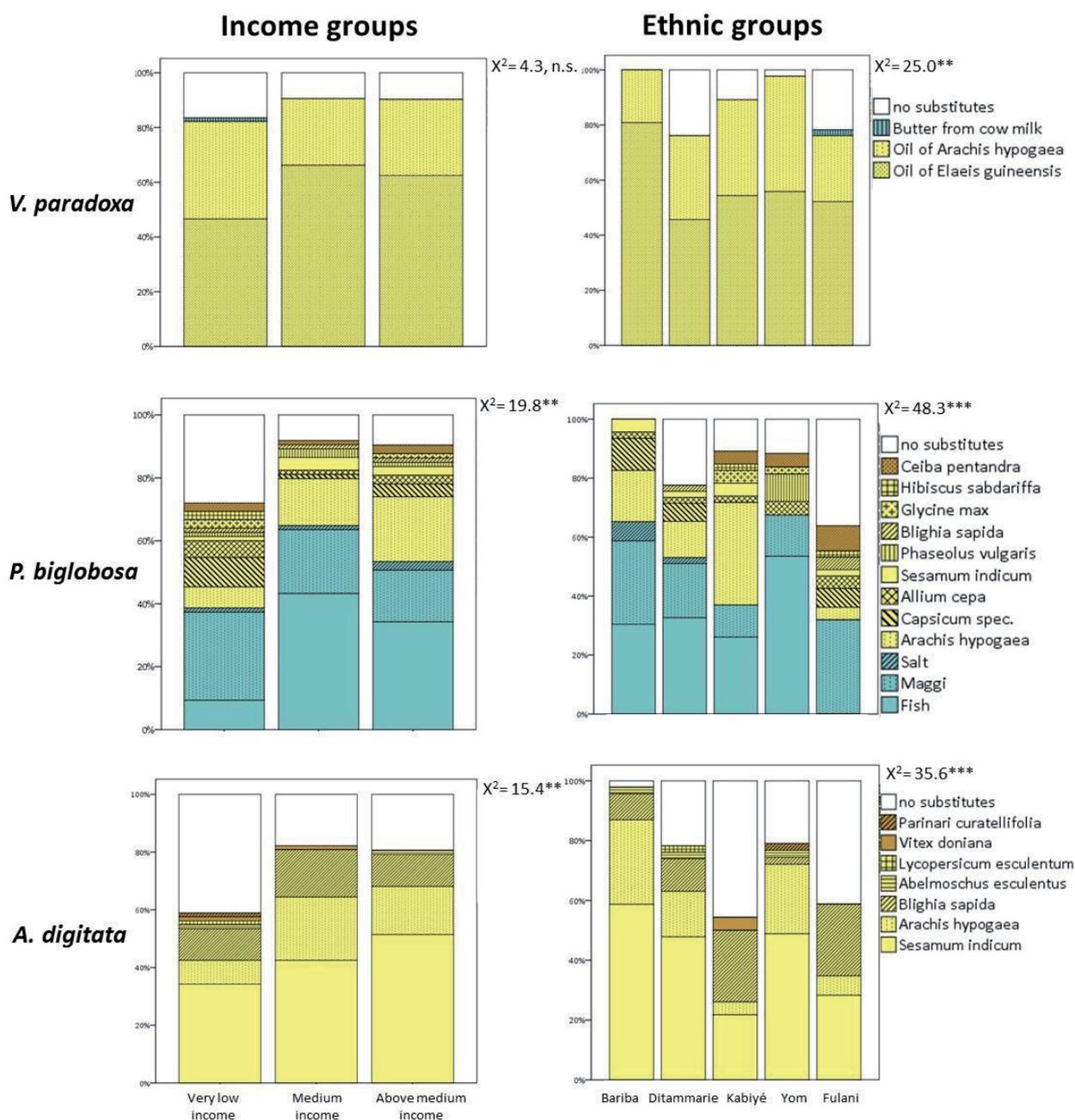


Fig. 2: Differences in substitution patterns of NTFPs between income and ethnic groups. Blue = animal/ other products; yellow = cultivated/ purchased plants; brown = other NTFP species. \*  $p < 0.05$ ; \*\*  $p < 0.01$ ; \*\*\*  $p < 0.001$ ; n.s. = not significant. / Différences dans les modèles de substitution des PFNL entre groupes économiques (de revenu) et groupes ethniques. Bleu = animal / autres produits; jaune = plantes cultivées / achetées; brun = autres espèces de PFNL. \*  $P < 0,05$ ; \*\*  $p < 0,01$ ; \*\*\*  $p < 0,001$ ; N.s. = Pas significatif.

For *A. digitata*, as much as 40 % of the sampled poorest households (and even 30 % and 20 % of the medium and above medium income groups, respectively) stated to have no replacement. Again, less poor households can afford to purchase more costly products (peanuts, sesame, seeds of *B. sapida*) while the poorest ones engage in the collection of the two wild plant species (*V. doniana* and *Parinari curatellifolia*) to use as substitute for sauce ingredient.

#### 4.3 Differences in substitution patterns between ethnicities

For all three species, our analysis revealed significant differences in substitution patterns between ethnic groups (Fig. 2): *A. digitata* ( $\chi^2=35.6$ ,  $p < 0.001$ ), *P. biglobosa* ( $\chi^2=48.3$ ,

$p < 0.001$ ) and *V. paradoxa* ( $\chi^2=25.0$ ,  $p < 0.01$ ). Albeit resembling regarding the total number of alternatives, they differ significantly especially for *P. biglobosa* (only two matches out of twelve substitutes) and *A. digitata* (only three matches out of seven substitutes).

Due to the very low number of alternatives, replacement of *V. paradoxa* seeds does not show great alterations between groups (except that the Fulani were the only ethnic group that mentioned cow butter as an additional substitute). In contrast, substitution patterns for *P. biglobosa* are highly differentiated between ethnic groups. Fish was mentioned as primary substitute by the four tiller societies Bariba, Ditammarie, Kabiyé and Yom, while the Fulani's first choice is MAGGI cubes when seeds of *P. biglobosa* are unavailable.

Moreover, the Bariba and the Ditammarie only mentioned cultivated and other merchandise as alternatives to *moutarde*, while the Kabiyé, the Yom and the Fulani also count on alternative wild plant species.

For the seeds of *A. digitata*, the Fulani only cited the three most important substitutes regarding the overall sample (sesame, peanuts, and the seeds of *B. sapida*), while the other ethnicities additionally reported other substitutes. For instance, the Ditammarie exclusively cited tomato, the Kabiyé leaves of *V. doniana*, and the Yom seeds of *P. curatellifolia*, with the latter being the only two wild plant species mentioned here.

Overall, about 15% of all substitutes reported by the Kabiyé and Yom were alternative wild plant species (Table 4). In contrast, the Ditammarie never mentioned other wild plant species as substitutes for the three investigated NTFPs.

Interestingly, the autochthon Bariba displayed the lowest proportion of respondents having no substitutes for the three species (Fig. 2), while particularly the Fulani seem to have difficulties to substitute the investigated NTFPs.

## 5 DISCUSSION

As our analysis shows, rural communities use a wide range of different products to substitute the seeds of the three investigated local NTFP species, *Vitellaria paradoxa*, *Parkia biglobosa* and *Adansonia digitata*. Of the 18 substitutes mentioned in total, 61 % are cultivated/purchased plants, 22 % animal or other products, and 17 % wild plant species collected in the adjacent savanna areas.

However, there are considerable differences in substitution patterns between both income groups and ethnic groups. From our figures, it becomes evident that income has a significant effect on the choice of alternatives, reflecting differences in financial resources to access these substitutes for the NTFPs under investigation. Being the ones with the least range of alternative products and least financial means to engage in pricy products, the poorest households are likely to be the ones most affected by the absence of the in-

vestigated NTFPs. Other wild plant species, thus, are essential to meet basic household needs as they are low cost opportunities with relatively easy access. In contrast, purchased/cultivated products are often pricy and sufficient quantities remain unaffordable for very poor households.

However, there may be justified assumption that a decreasing occurrence of *V. paradoxa*, *P. biglobosa* and *A. digitata* not only will hit the poorest but rather all their beneficiaries. Evidence is presented by a recent study conducted by HEBES et al. (2012) in Northern Benin who showed that the occurrence of the three target species and, subsequently, their contributions to household economies, will be severely affected by predicted land use and climate change until 2050. For *V. paradoxa*, losses of 20 % up to 50 % in 2050 are estimated for the study area. The same holds true for *P. biglobosa* (losses up to 50 %) and *A. digitata* (losses up to 20 %).

Subsequently, the daily supply of fat and protein as provided by these three species and, thus, their contributions to dietary needs, might be threatened in the future. This particularly holds true for shea nuts as there exist only few alternatives for them as our study showed. Even if the fat content of these substitutes is similar to that of shea nuts the fat quality might be lower, and their production costs, however, differ much compared to that of shea butter. While the manufacture of shea butter originally is an individual household-based activity carried out by women using firewood and simple wooden tools, the processing of peanut oil requires mills, i.e. technical equipment which normally is not affordable on a household level. Instead, households would need to pay mill owners. The production process of palm oil (*Elaeis guineense*) is by far the most expensive one, as interviewed women reported, including the harvest of the seeds. The subsequent processing requires larger machines and substantial energy use, which normally is centralized in specialized production sites. In addition, the palm tree is very scarce in the region, making its products far too expensive to be used on a daily basis. Furthermore, alternative products from other NTFP species to substitute *V. paradoxa* were not cited by our interviewees, and the production and use of butter from cow milk remains with merely a couple

**Table 4: Total number of substitutes for the three species, separated per income group and ethnicity. / Nombre total de substituts pour les trois espèces, séparés par groupe de revenu et groupe ethnique.**

	<i>V. paradoxa</i>	<i>P. biglobosa</i>	<i>A. digitata</i>	Share by category (%)		
				Product of a cultivated or purchased plant species	Product of a wild plant species	Purchased animal or other products
<b>Income groups</b>						
Very low income	3	12	7	63.6	18.2	18.2
Medium income	2	10	4	68.8	12.5	18.8
Above medium income	2	11	4	76.5	5.9	17.6
No. of substitutes overlapping*	<b>2</b>	<b>10</b>	<b>3</b>			
<b>Ethnic groups</b>						
Bariba	2	7	4	78.6	7.1	14.3
Ditammarie	2	8	5	80.0	0.0	20.0
Kabiyé	2	8	4	71.4	14.3	14.3
Yom	2	6	5	69.2	15.4	15.4
Fulani	3	8	3	78.6	7.1	14.3
No. of substitutes overlapping*	<b>2</b>	<b>2</b>	<b>3</b>			

\* among all groups

Fulani households owning few cattle. Apart from that, the calcium content of shea butter (340 mg/100 g; DEI 2008) by far exceeds that of peanuts (92 mg/100 g; ATAGA & VAN DER VOSSEN 2007), palm oil seeds (60 mg/100 g; NTARE 2007) and cow milk butter (72 mg/100 g; USDA 2002). This is in line with findings of LEAKEY (1999) who found that the biochemical profiles of native species are often superior to exotic species in terms of essential fat, micronutrients, fiber and protein. In contrast to the case of shea nuts, the options mentioned to replace protein-rich seeds of *P. biglobosa* are not as sufficient in terms of nutritional values (Table 5). Apart from peanuts and the seeds of the local species *Ceiba pentandra*, none of the alternatives cited reaches similar protein contents. Additionally, despite being an adequate nutritional substitute *C. pentandra* is very scarce in the study area – a possible reason for the low mention by respondents (3.5 %). This pattern is reflected for *A. digitata*. None of the seeds of the three cultivated plants reported as replacements equals its protein shares (Table 5), nor does the alternative wild local species *Vitex doniana*. However, being quite abundant in the region, the latter presents at least a low cost alternative.

In addition, those substitutes which compensate best in terms of fat and protein supply are all cultivated species (peanuts, sesame and *B. sapida*), i.e. they require access to farmland. This, however, often is limited for the poorest households as the size of farmland they manage is often insufficient (HEUBACH et al. 2011). Hence, we expected to find a greater proportion of other wild plant species used as substitutes, particularly among the poorer households. However, this is not the case. This might probably due to the low abundance of these species in the area as reported by the interviewees. Native species might also be less interesting if they have comparably lower productivities than e.g. crop species, which can be produced in relatively stable and controllable conditions (NEUFELDT et al. 2012), and generally are located nearby homes.

Beyond socio-economic characteristics, ethnic affiliation seems to play a considerable role in choosing substitutes for the three target species. Overall, in the study region, there is quite a range of species whose products are commonly valued by all investigated ethnic groups, such as the three species investigated here, plus a great range of NTFP species used considerably differently (HEUBACH et al. 2013). This is in line with findings of FANDOHAN et al. (2010) who identified use values for 76 plant species among three ethnic groups (Berba, Gourmantche and Waama) in Northern Benin, also highlighting the influence of gender and market proximity on plant use. Particularly woody species were most commonly used by all respondents, including the target species of the study at hand, while a whole set of other plant species were exclusively used by specific ethnic groups. This pattern is in accordance with other recent studies looking either at a collection of plant species (e.g. LYKKE et al. 2004; VODOUHÉ et al. 2009; PARÉ et al. 2010; SOP et al. 2012) or single species uses such as e.g. *Adansonia digitata* (DE CALUWÉ et al. 2009; SCHUMANN et al. 2011), *Tamarindus indica* (FANDOHAN et al. 2010) or *Sclerocarya birrea* (GOUWAKINNOU et al. 2011).

The reported differences reflect preferences of plant and other product use, often brought along from other regions through migratory activities (four of the five ethnic groups migrated into the study area). Particularly for *P. biglobosa* and *A. digitata*, there is only low intersection of substitutes between the five ethnic groups. Four of five groups engage in both purchasing/cultivating products and NTFP collection – except Ditammarie people. Additionally, the Ditammarie are among the two ethnic groups which frequently mentioned not to have alternatives at all; the other one is the Fulani group. In contrast, a high proportion of alternative NTFP species, as identified with the Kabiyé and Yom, might also indicate low financial means to access marketed products and/or limited access to farmland to cultivate them oneself. However, insights from HEUBACH et al. (2011) suggest that there is no significant difference regarding land holding between groups. To further understand the underlying reasons for the choice of substitutes more research at the household level is needed.

## 6 CONCLUSION

If the provision of seeds of *Vitellaria paradoxa*, *Parkia biglobosa* and *Adansonia digitata* is limited, rural communities in savanna areas could built on a wide range of cultivated, purchased or wild plant and animal products to substitute for these NTFPs. However, the three species of focus remain superior to all of their substitutes both in terms of their contribution to daily diets and accessibility. They generally exceed their alternatives in terms of protein, fat and micronutrients, and they are semi-open access resources readily available without requiring costly financial means or equipment. Thus, they are most attractive to the rural poor. However, this unique combination of characteristics also reflects the other side of the medal: maintaining the supply of those NTFPs is most crucial for the poorest households and thus will be a major future challenge to secure a healthy, self-sufficient food provision and income sources.

Subsequently, there is concern to maintain the availability of *V. paradoxa*, *P. biglobosa* and *A. digitata* in existing agroforestry systems. To support this, future research should have a closer look at how tree domestication, seed quality and genetic diversity of the three focus species could help to improve yields, and underlying reasons for substitution patterns to help developing appropriate management measures.

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