CONTRIBUTION OF NON-WOOD FOREST PRODUCTS TO HOUSEHOLD FOOD SECURITY IN THE MOYEN-CHARI PROVINCE OF SOUTHERN CHAD

Abstract

This study highlighted the local woody species exploited for human consumption by the four cantons (Niellim, Balimba, Djoli and Kokaga). The overall objective of the study was to determine the contribution of non-timber forest products (NTFPs) to food security in the four cantons of Chad's Moyen-Chari Province. The study was carried out through ethnobotanical surveys based on the food species consumed by humans, their families and the main threats to food woody species. The sample totalled 200 respondents, 50 from each canton. The woody species whose organs are used for human consumption comprised 48 edible woody species in the four cantons. These species are richest in Kokaga (35 species) and Balimba (35 species) cantons, followed by Djoli (31 species) and Niellim (30 species) cantons. The pulps, leaves, seeds, flowers and fruits of *Vitellaria paradoxa* (49.32%), *Detarium microcarpum* (43.60%) and *Parkia biglobosa* (40.46%) are more widely consumed in the four cantons. In Niellim canton, the top five woody food species in order of preference are: *Vitellaria paradoxa* (15.25%), *Detarium microcarpum* (11.86%), *Tamarindus indica* (11.86%), *Parkia biglobosa* (11.30%) and *Ziziphus abyssinica* (6.21%). Priority woody species in Canton Balimba are *Vitellaria paradoxa* (14.95%), *Parkia biglobosa* (12.29%), *Detarium microcarpum* (10.63%), *Vitex doniana* (8.31%) and *Ximenia americana* (7.97%). In Djoli canton, *Ziziphus abyssinica* (11.04%), *Balanites aegyptiaca* (9.03%), *Parkia biglobosa* (8.70%), *Detarium microcarpum* (8.36%) and *Ximenia americana* (7.36%). And finally, in Kokaga canton, we have *Detarium microcarpum* (11.86%), *Vitellaria paradoxa* (15.25%), *Parkia biglobosa* (11.30%), *Gardenia aqualla* (6.54%) and *Strychnos innocua* (6.21%). In all four cantons studied, the flowers are not overly edible. Fruits are more popular for human consumption in Balimba, Kokaga and Djoli than in Niellim, while seeds and leaves are more popular in Djoli and Kokaga than in Niellim and Balimba. The dominant families in the four cantons are Fabaceae (44%), Moraceae (20%), Combrataceae (12%) and Rubiaceae (12%). Threats common to these four cantons are the exploitation and over-exploitation of fruits and seeds, bush fires, ploughing and clearing of fields, and the low and very low regeneration of certain woody food species. This study constitutes a starting point for decision-making in the sustainable management of the lean season. The results of this study will help to guide conservation and development programs for woody food species in the study area.

Key words: Contribution, Moyen-Chari, local perceptions, Chad, food vegetation

1. Introduction

In sub-Saharan Africa, it is widely recognized that populations rely on natural resources, particularly forest resources, to ensure their survival (Dembélé *et al*., 2016). The importance of non-timber forest products (NTFPs) and their contribution to food security and poverty reduction (Loubelo, 2012; Badjaré *et al*., 2018) is generally underestimated because most of them do not appear in national economic statistics (FAO, 2010). NTFPs occupy an important place in the traditional livelihoods and culture of the Sahelian populations. These resources occupy a prominent place in the daily lives of these populations thanks to their multiple uses (FAO, 2011; Dembélé *et al*., 2016). These natural resources present, for local and developing populations, a certain interest and socio-economic balance and allow them to satisfy their basic needs (Guigma *et al*., 2012; Badjaré *et al*., 2018). For vulnerable farmers with low average annual incomes, wild plant species provide a food alternative (Guimbo *et al*., 2012). They provide survival food during lean periods, drought years, and supplementary food during periods of abundant rainfall in the Sahel (Ouedraogo *et al*., 2013) and are also the subject of significant commercial income-generating activities for rural populations, particularly women and children who are heavily involved in the harvesting and marketing of these products (Hama *et al*., 2010; Hama *et al*., 2019). These NTFPs can be harvested in the wild, or produced in forest plantations or agroforestry parks or from trees outside forests (Loubelo, 2012). Numerous studies have shown the importance of plant species in human diet in Africa (Guigma *et al*., 2012; Dembélé *et al*., 2016; Ado *et al*., 2016; Ayena *et al*., 2016; Badjaré *et al*., 2018; Hama *et al*., 2019; Assogbadjo *et al*., 2021; Rousou, 2022). These plants include woody and herbaceous plants. Food woody species include all woody plants that provide leaves, flowers, fruits, seeds, pods, sap, bark or other parts used for human consumption (Thiombiano *et al*., 2014; Ado *et al*., 2016). Consumption depends on the periods and years. Humans often use these food woody species to meet their food needs, for service wood, energy wood, livestock fodder and traditional pharmacopoeia (Waya , 2023) or as a source of income (Djibo *et al*., 2020). For others, the exploitation of these non-timber forest products constitutes their crisis response strategies when drought leads to poor harvests. Livelihood diversification, particularly through non-timber forest products, is the main strategy used in Tanzania to anticipate climate variability (Paavola, 2008; Djibo *et al*., 2020). Endogenous knowledge is an essential component of local biodiversity conservation (Pilgrim, *et al*., 2007). It is therefore necessary to understand the local knowledge of the rural

population to detect any changes in the flora (Mccorkle, 1989) and have a good understanding of the use of woody food species (Djibo *et al*., 2020). The general objective of this study is to understand the contribution of NTFPs to food security in the four cantons of the Moyen-Chari Province of Chad. The aim is to determine all the organs of the woody species exploited for consumption and their families.

2. Materials and Methods

2.1. Study Site

The study sites are Kokaga Canton, Balimba Canton, Djoli Canton, and Niellim Canton. The four cantons are part of the Moyen-Chari province and located in the southern part of Chad (Figure 1). The area is characterized by a dry tropical climate and Sudanian bioclimatic, with an average annual precipitation of 1000 mm (the rainy season lasts approximately 6 months), an average annual temperature of 24.5°C, and relative humidity ranging from 32 to 85% depending on the month (ASECNA, 2018). The soil types are: erosion soils on acid rocks dominant on Mount Niellim, sesquioxides with ferruginous stains and concretions and cuirasses, and hydromorphic soils characteristic of the Djoli, Kokaga, Balimba, and Niellim cantons. The vegetation formations are shrub and wooded savannahs. Overall, the vegetation is of the Sudanese type, the density and distribution of which depend on the topography and the nature of the soil (PAPNM, 2010). The population of these cantons is mainly composed of Sar-Madjingaye, Mbaye, Daï, Arabe, Sara-Kaba, Tounia, Boua, Toumak, Niellim and Ndam.

2.2. Sampling and Data Collection Methods

The stratified sampling adopted by Atakpama *et al*., 2012; Zabouh, 2014; Badjaré *et al*., 2018 was used. Two strata were distinguished: the first consists of the four target cantons of Moyen-Chari: Niellim, Djoli, Kokaga, and Balimba. The second stratum consists of 16 villages from these four cantons. For the ethnobotanical survey of woody food species, 16 villages belonging to the four cantons were selected, with four villages per canton (Table 1). These villages were chosen to cover all ethnic groups present in each canton, based on the intense anthropogenic activities carried out on NTFPs, and their location in relation to Manda National Park.

The data collection methods were mainly based on semi-structured interviews, focusing mainly on populations, traditional leaders and water and forestry agents at the level of the different cantons to collect information on the most consumed food species in their canton, the organs of the species used and the threatened species. The questionnaire included closed questions (which are answered yes or no), open questions (which are answered deliberately according to one's point of view) and directed questions (some answers are proposed to the respondents). The sample consists of 200 people (Table 1). The individual interview is adopted and specifically the face-to-face interview, because it allows to achieve the highest response rate to the greatest number of questions (Arouna, 2012). The choice was much more focused on women, since they are the ones who value NTFPs and especially food more. Individual interviews were facilitated by the help of interpreters fluent in local dialects (Sara, Niellim, Boua, Arabic and Tounia). The species cited during the survey were determined from

their local names, then collected in the fields and identified by botanists from the University of Sarh, botanical lexicons and reference documents (Ligneux du sahel, 2008; Arbonnier, 2009; Flore illustrée du Tchad, 2019).

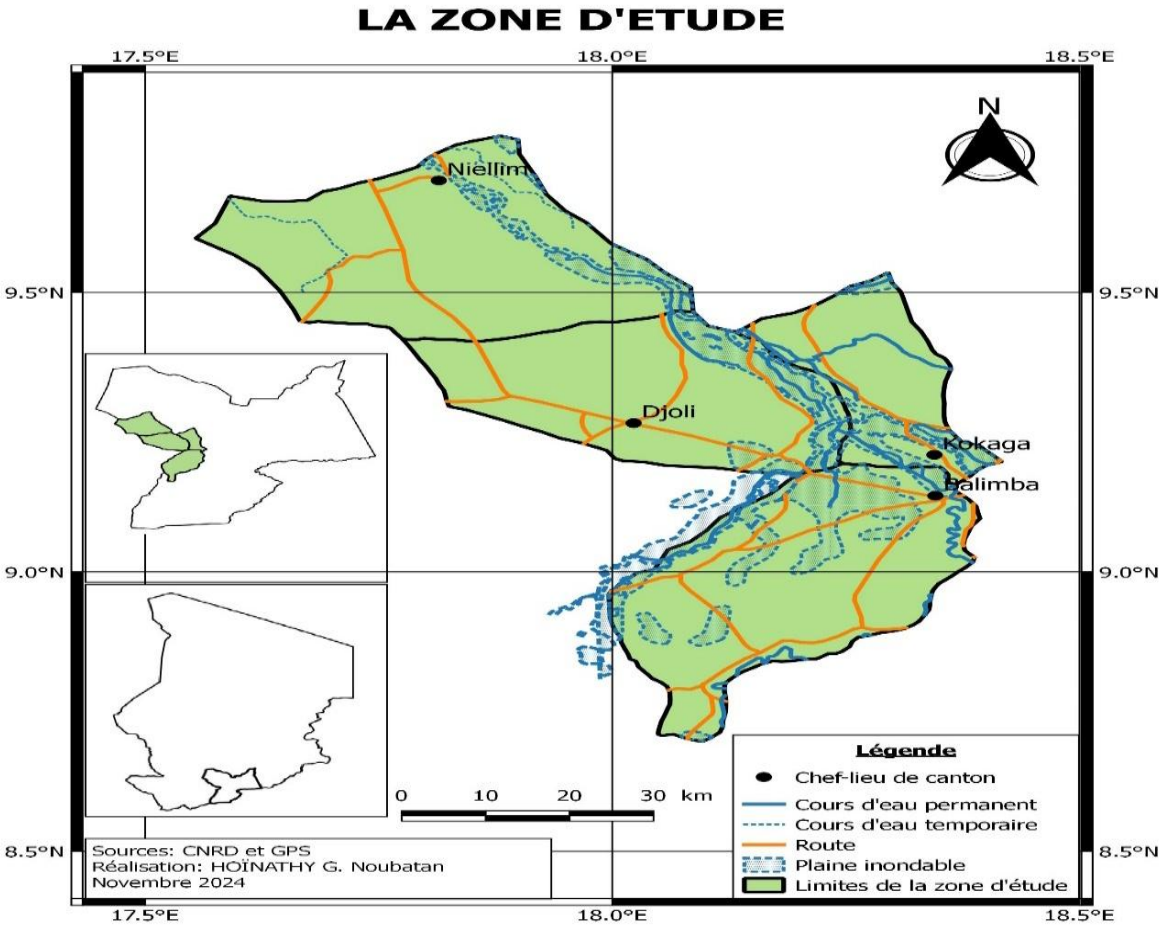

Figure 1: Map of the study area

Table 1: Sampled villages in the four cantons

Canton	villages	Households	Households surveyed
Manda	Manda I	173	17
	Matta	53	10
	Taholo	56	10
	Mandjikaga	80	13
Kokaga	Maïnroum	100	16
	Dyba-sya	35	10
	Bainaka	40	12
	Ngangolo	36	12
Djoli	Djoli	120	16
	Sanguelé	53	13
	Doboro	36	10
	Doguigui	50	12

Niellim	Photoum	60	13
	Wain	36	10
	Niellim	82	16
	Falké	47	11
	TOTAL	**1056**	**200**

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127 2.3. Threats to woody food and priority species

128 The methodology adopted to determine the threats to woody food and priority species was to
129 rank each potential threat for each priority species in each canton using the method used by
130 Ado and his colleagues in 2016, with the following points: 0 = not threatened; 1 = slightly
131 threatened; 2 = threatened; 3 = highly threatened; 4 = The species' status is unknown.

132 2.4. Data Processing

133 The collected data were entered into Excel software. To list all NTFPs consumed in the four
134 cantons, the organs of the woody species harvested, and calculate the percentage, we used
135 SPSS Statistics 22 software. The order of importance of each species among the five priority
136 species cited by each canton was expressed as a percentage and calculated by the ratio of each
137 species' score to the total score, taking into account the responses of all respondents in order
138 to rank the priority species. We performed a descriptive statistical analysis of the NTFP plant
139 species.

140 3. Results and Discussion

141 3.1. Organs of Species Exploited for Food by Canton

142 The woody species whose organs are used for human consumption consist of 48 woody food
143 species in the four cantons (Table 2; Figure 2). These species are richest in the Kokaga (35
144 species) and Balimba (35 species) cantons, followed by the Djoli canton (31 species) and the
145 Niellim canton (30 species) (Table 2). Only 37.5% of these species (18 species) are common
146 to all four cantons (Table 2). The pulp, leaves, seeds, flowers, and fruits of *Vitellaria*
147 *paradoxa* (49.32%), *Detarium microcarpum* (43.60%), and *Parkia biglobosa* (40.46%) are
148 most consumed in the four cantons (Figure 2). The fruits of *Vitellaria paradoxa* are highly
149 valued and consumed by the population of the study area. The flowers of *Parkia biglobosa*
150 are sucked by children (waya, 2023), its powdered leaves are well consumed and its flowers
151 and fruits (pulp) are used in the manufacture of sweet drinks (Thiombiano *et al*., 2012). These
152 pulps are energetic when transformed into pasta and consumed alone or in combination with
153 millet flour (Thiombiano *et al*., 2012). Its seeds, especially fermented, are very popular
154 condiments in sauces and are substitutes for flavorings (Maggie) (waya, 2023). For *Detarium*
155 *microcarpum*, not only are its fruits edible, rich in vitamin C (Anonymous, 2008), but locally
156 marketed (waya, 2023). *Detarium microcarpum* and *Vitellaria paradoxa* are regularly used to
157 cover energy needs (Guigma *et al*., 2012). All these species are found throughout the cantons
158 and are in their preferred area. Badjaré *et al*. (2018) in their research on "Ethnobotanical study
159 of woody species of dry savannahs in Northern Togo: diversity, uses, importance and
160 vulnerability", also found that among the most common useful woody species, there are

Vitellaria paradoxa, *Parkia biglobosa*, *Detarium microcarpum* and *Vitex doniana*. The fruits and seeds of *Ziziphus abyssinica* are more appreciated in the Djoli canton (11.04%) than the Niellim canton (6.21%). The pods, flowers and fruits of *Tamarindus indica* are also highly valued in the Niellim canton. The fruits of *Vitex doniana* are widely consumed in the Balimba canton (8.31%). The fruits, pods and seeds of *Balanites aegyptiaca* are highly valued in the Djoli canton (9.03%), while in the Kokaga canton, the fruits of *Gardenia aqualla* and the pulp and seeds of *Strychnos innocua* are valued respectively (6.54%) and (6.21%). In addition to their fresh consumption, these fruits can be dried, grilled, or used in food preparations (Rousou, 2022). In addition, they can be processed or treated for the production of other products, such as for oil extraction (Rousou, 2022). For example, shea oil is extracted by grinding or crushing the fruit, as suggested by ethnobotanical data.

This first place ranking obtained by *Vitellaria paradoxa* has also been reported by many authors (Diop *et al*., 2005; Belem *et al*., 2008; Guigma *et al*., 2012; Dembélé *et al*., 2016). This position shows the importance of this woody species for the populations. Faye *et al*. (2010) cited by Dembélé *et al*. (2016) who noted that the fruits of *Vitellaria paradoxa* are widely consumed raw for their pulp by the populations in the Ségou region during the lean period which corresponds to the rainy season. This is confirmed by the population of the study area, during our survey. The exploitation of the organs of these non-timber forest products constitutes their response strategies to a crisis when drought leads to poor harvests (Djibo *et al*., 2020). Each exploited part has a disadvantage on the survival of the species (Guigma *et al*., 2012). Overexploitation of vegetative organs (roots, leaves, flowers, bark, wood) leads to physiological disorders and a drop in productivity (Guigma *et al*., 2012). The use of seeds and flowers prevents the seminal regeneration of species (Taita, 2003; Guigma *et al*., 2012).

Table 2: Woody species used in human food and products consumed in the four cantons

SPECIES	**CONSUMED ORGANS**	**Number of times species cited as a percentage (%) in the 04 cantons**				
		NIELLIM	**BALIMBA**	**DJOLI**	**KOKAGA**	**TOTAL(%)**
Afzelia africana	*Flowers*	0,56	0	0	0,33	0,89
Amblygonocarpus andongensis	*Fruits, Flowers, Seeds*	0	0	0	0,33	0,33
Annona senegalensis	*Leaves, Flowers, Fruits*	0	3,32	0,67	0,33	4,32
Balanites aegyptiaca	*Fruits, Pods, Seeds*	2,82	0,66	9,03	1,63	14,15
Borassus aethiopum	*Terminal bud, Sap, Seedling*	3,39	0,66	0,67	0,65	5,38
Cassia sieberiana	*Pods*	0	0	0,33	0	0,33
Combretum collinum	*Gum*	0	0,33	0	0	0,33
Combretum glutinosum	*Leaves*	0	0,33	0	0	0,33

Cordia africana	Fruits, Seeds	0	0,33	0	0	0,33
Crossopteryx febrifuga	Leaves, Fruits	0	0,33	0,33	0	0,67
Daniellia oliveri	Seeds, Fruits	0	0,33	0	0	0,33
Detarium microcarpum	Pulps, Leaves	11,86	10,63	8,36	12,75	43,6
Dioscorea dumetorum	Fruits, Leaves	1,13	0,33	0,67	1,96	4,09
Diospyros mespiliformis	Leaves, Pulps	0,56	4,65	2,34	0,98	8,54
Euphorbia kamerunica	Saps	1,13	0	0	0	1,13
Ficus dekdekena	Bark	0	0	0	0,33	0,33
Ficus glumosa	Figs	2,82	1,33	2,34	2,29	8,78
Ficus ingens	Figs	0	0	2,01	1,96	3,97
Ficus platyphylla	Leaves, Figs	0	0,66	0	0,65	1,32
Ficus sycomorus	Bark, Leaves	0,56	1,99	2,34	1,63	6,53
Gardenia aqualla	Fruits	4,52	0	6,02	6,54	17,08
Grewia cissoides	Fruits	0	1,33	0	0	1,33
Grewia venusta	Fruits, Bark, Leaves	5,65	1,66	0,67	3,59	11,57
Hexalobus monopetalus	Fruits	1,13	5,98	1,67	4,58	13,36
Hymenocardia acida	Leaves, Fruits	1,13	1,66	0	2,29	5,08
Hyphaene thebaica	Almond	1,13	1	7,02	0,98	10,13
Khaya senegalensis	Inflorescence	0	1	0	0	1
Mimosa pigra	Fruits	0	1	1,67	0,33	3
Moringa oleifera	Leaves, Fruits, Seeds, Flowers	2,26	0	0,67	0,98	3,91
Parinari curatellifolia	Almond, Fruits	1,69	1,66	0	1,63	4,99
Parkia biglobosa	Leaves, Flowers, Fruits, Seeds	11,3	12,29	8,7	8,17	40,46
Pericopsis laxiflora	Flowers	0	0,33	0	0	0,33
Pterocarpus erinaceus	Flowers	0,56	1,66	0,33	1,96	4,52
Saba senegalensis	Pulps	0,56	0	0	0	0,56
Sarcocephalus latifolius	Pulps	0,56	0	0,33	0,65	1,55
Scadoxus multiflorus	Fruits, Leaves	1,13	0,66	2,68	0,65	5,12
Sclerocarya birrea	Almond, Pulps	0	0,33	1	0,33	1,66

Securidaca longipedunculata	Leaves, Flowers	0	0	0	0,65	0,65
Strychnos innocua	Pulp, Seeds	0	3,99	1,67	6,21	11,87
Strychnos spinosa	Leaves, Fruits, Seeds	1,69	0,33	0	3,27	5,3
Swartzia madagascariensis	Seeds	1,13	0	1,34	1,63	4,1
Tacca leontopetaloides	Flowers	1,13	0	0,67	0	1,8
Tamarindus indica	Pods, Flowers, Fruits	11,86	2,99	5,35	3,92	24,13
Terminalia laxiflora	Leaves	1,13	0,66	0,33	0	2,13
Vitellaria paradoxa	Pulp, Fruits, Seeds	15,25	14,95	7,02	12,09	49,32
Vitex doniana	Fruits	3,95	8,31	5,35	3,92	21,53
Ximenia americana	Fruits, Leaves	1,13	7,97	7,36	4,9	21,36
Ziziphus abyssinica	Pulp, Seeds	6,21	4,32	11,04	4,9	26,47
	Total	**100**	**100**	**100**	**100**	**4000**

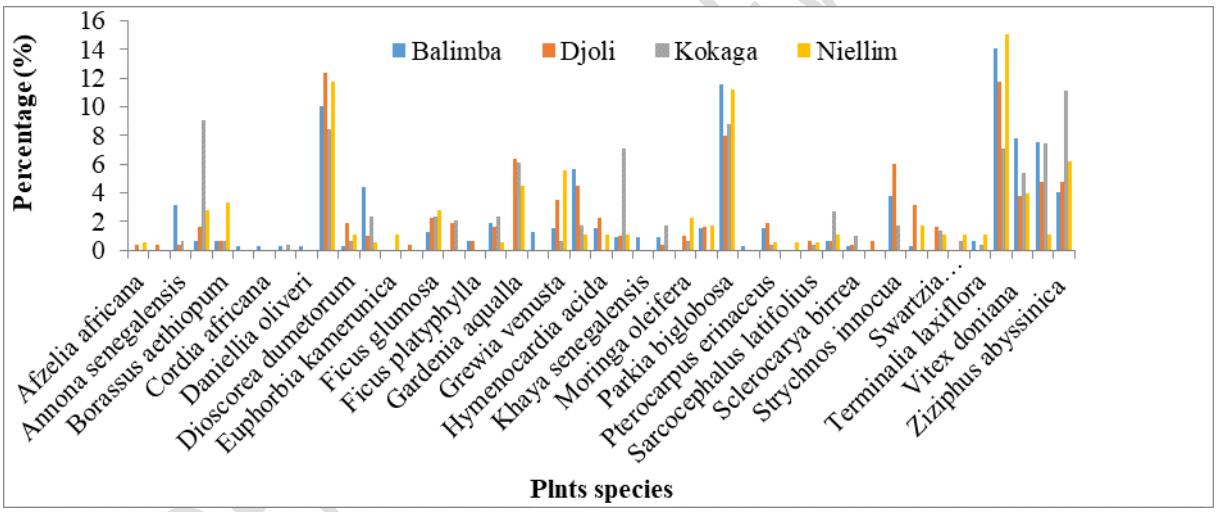

Figure 2: Woody species used in human food in the 04 Cantons

3.2. Priority woody food species in the four cantons

In the Niellim canton, the five priority woody food species, in order of preference, are: *Vitellaria paradoxa* (15.25%), *Detarium microcarpum* (11.86%), *Tamarindus indica* (11.86%), *Parkia biglobosa* (11.30%), and *Ziziphus abyssinica* (6.21%). The priority woody species in the Balimba canton are *Vitellaria paradoxa* (14.95%), *Parkia biglobosa* (12.29%), *Detarium microcarpum* (10.63%), *Vitex doniana* (8.31%), and *Ximenia americana* (7.97%). As for the Djoli canton, these are *Ziziphus abyssinica* (11.04%), *Balanites aegyptiaca* (9.03%), *Parkia biglobosa* (8.70%), *Detarium microcarpum* (8.36%) and *Ximenia americana* (7.36%). And finally in Kokaga canton, we have *Detarium microcarpum* (11.86%), *Vitellaria paradoxa* (15.25%), *Parkia biglobosa* (11.30%), *Gardenia aqualla* (6.54%) and *Strychnos innocua* (6.21%) (Table 2). There are woody food species that have more than one edible

organ (*Vitellaria paradoxa, Detarium microcarpum, Parkia biglobosa, Moringa oleifera, Borassus aethiopum* etc.) while some have only one (*Gardenia aqualla, Tacca leontopetaloides, Terminalia laxiflora, Vitex doniana*). The number of organs consumed varies from one woody species to another but also from local knowledge (Djibo *et al*., 2020). In the four cantons studied, the flowers are not very edible. Fruits are more sought after in human food in the cantons of Balimba, Kokaga and Djoli than in the canton of Niellim on the one hand, and seeds and leaves are more preferred in Djoli and Kokaga than in Niellim and Balimba. Djibo and his colleagues in 2020 in their study, found that leaves, fruits, flowers and seeds are sought after and edible in the study area. Dietary habits would play a determining role in the choice of preferred woody food species (Djibo *et al*., 2020). This is the case of *Parkia biglobosa* and *Vitellaria paradoxa*, an area known for its high consumption of these species during lean periods.

Table 2: Classification of welding plants in order of priority

Cantons	Niellim			Balimba			Kokaga			Djoli		
Rank	**Species**	**Citation numbers**	**%**	**Species**	**Citation numbers**	**%**	**Species**	**Citation numbers**	**%**	**Species**	**Citation numbers**	**%**
1ere	*Vitellaria paradoxa*	27	15,25	*Vitellaria paradoxa*	45	14,95	*Detarium microcarpum*	39	12,75	*Ziziphus abyssinica*	33	11,04
2e	*Tamarindus indica*	21	11,86	*Parkia biglobosa*	37	12,29	*Vitellaria paradoxa*	37	12,09	*Balanites aegyptiaca*	27	9,03
3e	*Detarium microcarpum*	21	11,86	*Detarium microcarpum*	32	10,63	*Parkia biglobosa*	25	8,17	*Parkia biglobosa*	26	8,70
4e	*Parkia biglobosa*	20	11,30	*Vitex doniana*	25	8,31	*Gardenia aqualla*	20	6,54	*Detarium microcarpum*	25	8,36
5e	*Ziziphus abyssinica*	11	6,21	*Ximenia americana*	24	7,97	*Strychnos innocua*	19	6,21	*Ximenia americana*	21	7,36

3.3. Families of species harvested for consumption in each canton

The dominant families in the four cantons are Fabaceae (44%), Moraceae (20%), Combrataceae (12%), and Rubiaceae (12%) (Table 3). Fabaceae and Moraceae are more frequently mentioned in Kokaga canton (42.10%; 26.31%) than in Djoli (38.88%; 16.66%), Balimba (35%; 15%), and Niellim (28.57%; 9.52%) cantons, while Rubiaceae were more frequently represented in Djoli (16.66%) and Kokaga (15.78%) cantons than in Niellim (9.52%) and Balimba (5%) cantons. The Combrataceae family is more frequently used in Balimba canton (15%) than in the other cantons (Table 3). These results show that the woody food species whose organs are consumed by the populations surveyed and living in the study area are made up of 25 families, including 21 in the Niellim canton, 20, 18 and 19 families respectively in the Balimba, Djoli and Kokaga cantons. These families of woody food species are different from the families found (Ceasalpiniaceae, Anacardiaceae and Capparaceae) by Djibo *et al*. (2020) during their research on "Local perception on the state of spontaneous woody food species and their role: case of the rural communes of Tamou and Simiri in Niger". The difference in the families of woody food species between the four cantons could be explained by the mode of dissemination and the degree of adaptation of most of the species constituting these dominant families (Djibo *et al*., 2020), on the one hand, and the preferences of its populations or the availability of these families on the other hand.

Table 3: Families of NTFPs of plant origin, exploited in the 04 cantons of the Province of Moyen-Chari

Families	**Niellim**	**Balimba**	**Djoli**	**Kokaga**	**Total**
Amaryllidaceae	1 (4,76%)	1 (5%)	1 (5,55%)	1 (5,26%)	1 (4%)
Anacardiaceae	0 (0%)	1 (5%)	1 (5,55%)	1 (5,26%)	1 (4%)
Annonaceae	1 (4,76%)	2 (10%)	2 (11,11%)	2 (10,52%)	2 (8%)
Apocynaceae	1 (4,76%)	0 (0%)	0 (0%)	0 (0%)	1 (4%)
Arecaceae	2 (9,52%)	2 (10%)	2 (11,11%)	2 (10,52%)	2 (8%)
Balanitaceae	1 (4,76%)	1 (5%)	1 (5,55%)	1 (5,26%)	1 (4%)
Boraginaceae	0 (0%)	1 (5%)	0 (0%)	0 (0%)	1 (4%)
Chrysobalanaceae	1 (4,76%)	1 (5%)	0 (0%)	1 (5,26%)	1 (4%)
Combrataceae	1 (4,76%)	3 (15%)	1 (5,55%)	0 (0%)	3 (12%)

Dioscoreceae	2 (9,52%)	2 (10%)	2 (11,11%)	2 (10,52%)	2 (8%)
Euphorbiaceae	1 (4,76%)	0 (0%)	0 (0%)	0 (0%)	1 (4%)
Fabaceae	6 (28,57%)	7 (35%)	7 (38,88%)	8 (42,10%)	11 (44%)
Lamiaceae	1 (4,76%)	1 (5%)	1 (5,55%)	1 (5,26%)	1 (4%)
Loganiaceae	1 (4,76%)	2 (10%)	1 (5,55%)	2 (10,52%)	2 (8%)
Malvaceae	1 (4,76%)	2 (10%)	1 (5,55%)	1 (5,26%)	2 (8%)
Meliaceae	0 (0%)	1 (5%)	0 (0%)	0 (0%)	1 (4%)
Moraceae	2 (9,52%)	3 (15%)	3 (16,66%)	5 (26,31%)	5 (20%)
Moringaceae	1 (4,76%)	0 (0%)	1 (5,55%)	1 (5,26%)	1 (4%)
Phyllanthaceae	1 (4,76%)	1 (5%)	0 (0%)	1 (5,26%)	1 (4%)
Polygalaceae	0 (0%)	0 (0%)	0 (0%)	1 (5,26%)	1 (4%)
Rhamnaceae	1 (4,76%)	1 (5%)	1 (5,55%)	1 (5,26%)	1 (4%)
Rubiaceae	2 (9,52%)	1 (5%)	3 (16,66%)	3 (15,78%)	3 (12%)
Sapotaceae	1 (4,76%)	1 (5%)	1 (5,55%)	1 (5,26%)	1 (4%)
Taccaceae	1 (4,76%)	0 (0%)	1 (5,55%)	0 (0%)	1 (4%)
Ximeniaceae	1 (4,76%)	1 (5%)	1 (5,55%)	1 (5,26%)	1 (4%)
TOTAL	**21**	**20**	**18**	**19**	**25**

3.4. Threats to Food and Priority Species in the Four Cantons

Analysis of the research results reveals the main threats to the five priority food species in each canton of the study area (Table 4). Threats common to these four cantons are the

exploitation and overexploitation of fruits and seeds, bushfires, plowing and clearing of fields, and the low and very low regeneration of certain woody food species. In addition to threats common to the four cantons, in Niellim, there is the exploitation of *Tamarindus indica* flowers and fruits and the exploitation of *Ziziphus abyssinica* fruits and bark; in Balimba, there is the exploitation of *Vitex doniana* fruits and the exploitation of *Ximenia americana* leaves and fruits, in Djoli, there is the overexploitation of fruits and seeds and the aging of *Balanites aegyptiaca* and the exploitation of *Ximenia americana* leaves and fruits and finally in Kokaga, there is the exploitation of *Gardenia aqualla* fruits and the exploitation of *Strychnos innocua* seeds (Table 4). Threats such as overexploitation, exploitation, fires and clearing are reported by Ado *et al*. (2016) but it is mainly aging for *Balanites aegyptiaca*. This local perception reflects the particular importance that populations attach to these woody food species. Indeed, *Vitellaria paradoxa* and *Parkia biglobosa* play a socio-economic role very appreciated by local populations (Guimbo *et al*., 2012). The exploitation of immature fruits was reported by the surveyed population and it is difficult to find *Vitellaria paradoxa* seeds to ensure regeneration. This observation is confirmed by the work of Soumana *et al*. (2010). Population growth and the increase in demand for plant products, some species are in decline in specific localities (Guigma *et al*., 2012). Soil depletion has a significant impact on these priority plants (Ado *et al*., 2016). The disappearance of these emblematic resources is justified by the overexploitation of their organs to meet human needs but also overgrazing. (Djibo *et al.*, 2020).

Table 4: Main threats to priority woody food species

Scientific Names	**Main Threats**	**Niellim (%)**	**Balimba (%)**	**Djoli (%)**	**Kokaga (%)**
Vitellaria paradoxa	Overexploitation of fruits and seeds, bushfires, aging, plowing and clearing of fields	15,25	14,95	-	12,09
Tamarindus indica	Exploitation of flowers and fruits	11,86	-	-	-
Parkia biglobosa	Overexploitation of seeds, plowing and clearing of fields, poor regeneration	11,3	12,29	8,70	8,17
Detarium microscarpum	Very poor regeneration and exploitation of fruits	11,86	10,63	8,36	12,75
Ziziphus abyssinica	Exploitation of fruits and bark	6,21	-	11,04	-
Vitex doniana	Exploitation of fruits	-	8,31	-	-
Ximenia americana	Exploitation of leaves and fruits	-	7,97	7,36	-
Balinetes aegyptiaca	Overexploitation of fruits and seeds, aging	-	-	9,03	-
Gardenia aqualla	Exploitation of fruits	-	-	-	6,54
Strychnos innocua	Exploitation of seeds	-	-	-	6,21

Conclusion

This research, whose results complement previous studies on the exploitation, management, and use of woody food plants in general and in the Moyen-Chari province of southern Chad in particular, represents an essential contribution of non-timber forest products to household food security. The Niellim, Balimba, Djoli, and Kokaga cantons are rich in woody food species used not only as a dietary supplement but also to cope with the lean season through the consumption of various organs (leaves, flowers, fruits, pulp, pods, seeds, etc.). Some woody food species are overexploited, aging, and threatened with extinction (*Vitellaria paradoxa, Parkia biglobosa*, *Ziziphus abyssinica,* and *Balinetes aegyptiaca*). To reduce the erosion of the biodiversity of these woody food species, restoration and conservation strategies are needed for the sustainable use of these priority species, which are highly valued by the population. In short, all species provide the substances (carbohydrates, proteins, lipids, vitamins and mineral salts) necessary for life. It remains to be verified that this qualitative contribution is also quantitative to ensure the nutritional balance of man.

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