Universität für
Bodenkultur Wien
Department für
Nachhaltige Agrarsysteme
Institut für Ökologischen Landbau
AG Wissenssysteme und Innovationen

The personal food environment and its influences on the consumption of neglected and underutilised plant species in the region of Atacora (northern Benin)

Master thesis

Submitted by:
Lynn Carole Julen, Bsc
Matriculation No.: 11726224
Study ID: UH 066 500

Supervisor:
Ao.Univ.Prof. Dipl.-Ing. Dr.nat.techn. Christian R. Vogl
Co-Supervisors:
Prof. Dr. Andrea Knierim
Ass.Prof. Dipl.-Ing. Dr. Christoph Schunko

Working Group Knowledge Systems and Innovation
Division of Organic Farming
Department for Sustainable Agricultural Systems
University of Natural Resources and Life Sciences, Vienna

Sierre, November 2020

Acknowledgements

I would like to first thank all interview partners who shared their valuable knowledge, experiences, and time. I am very grateful for their openness to participate in this study and for the exchanges we had.

A special thanks goes to the team of enumerators Boris Biagri and Vincent Offio who helped me to collect the data during the field research in the Atacora region in Benin. Without you, the data collection would not have been possible in this way and I am very grateful for your commitment. Also thank you, Malikath Bankole, doctoral student at the University of Abomey-Calavi in Cotonou, for your support during the data collection process and your accompany, which made my stay in Benin so much more fun.

Thanks to the team of ProSAR at the GIZ in Natitingou, who assisted me in preparing and implementing the data collection and gave us the opportunity to use their premises. A special thanks goes to Nadescha Beckmann, Estelle Adjovi, Bianca Oebel and Lambert for your support.

I would also like to thank the researchers of Bioversity international and the International Center for Tropical Agriculture as well as from the University of Abomey-Calavi in Cotonou behind the research project with the title: “Enhancing consumer demand and uptake of nutritious underutilised plant species in the region northern Benin”. Thank you, Julia Boedecker, for enabling me to participate in this project and for your support. Thank you, Dr. Mathilde Savy, Prof. Waliou Amoussa Hounkpatin and Fifali Sam Ulrich Bodjrenou, for your assistance during the field research and your valuable inputs.

I am very grateful for the competent support and expertise of my supervisor Ao.Univ.Prof. Dipl.-Ing. Dr.nat.techn. Christian R. Vogl and my co-supervisors Prof. Dr. Andrea Knierim and Ass.Prof. Dipl.-Ing. Dr. Christoph Schunko. I would like to especially thank you, Christoph, for being available for any questions at any time, for your ideas and constructive inputs to my work.

Furthermore, thanks to the “Studiendekanat” of the University of Natural Resources and Life Sciences in Vienna who provided me with the financial means for my stay in Benin through the scholarship I received.

Above all, I want to thank my family and friends for the support, patience and motivation you gave me during this time.

Abbreviations

CIAT ..... *International Center for Tropical Agriculture*

FNS-ER ..... *Food and Nutritional Security - Enhanced Resilience*

FSA/UAC ..... *Faculty of Agricultural Sciences of the University of Abomey-Calavi*

GIZ ..... *Deutsche Gesellschaft für Zusammenarbeit*

LMIC ..... *Low- and Middle-Income Countries*

NUCS ..... *Neglected and Underutilised Crop Species*

NUS ..... *Neglected and Underutilised Species*

OWNH ..... *One World - No Hunger*

ProSAR ..... *Global Programme on Food and Nutrition Security, Enhanced Resilience*

Kurzfassung

Julen, Lynn Carole. 2020. Das persönliche Nahrungsumfeld und dessen Einflüsse auf den Konsum von vernachlässigten Pflanzenarten in der Region Atakora (Nord-Benin), Masterarbeit an der Universität für Bodenkultur, Wien.

Obwohl der afrikanische Kontinent in Bezug auf essbare, wildwachsende und kultivierte Pflanzenarten als die vielfältigste Region der Welt gilt, ist insbesondere Sub-Sahara Afrika von hoher Ernährungsunsicherheit betroffen. Was die Anforderungen an eine gesunde Ernährung betrifft, so bleibt das Potenzial vieler essbarer Pflanzenarten wenig genutzt. Um die Einflüsse des persönlichen Nahrungsumfeldes auf den Konsum vernachlässigter Pflanzenarten im Departement Atakora im Norden Benins besser zu verstehen, untersuchte diese Studie Veränderungen des Konsums von 16 Pflanzenteilen (Blätter, Fruchtfleisch und Samen) von 11 Arten, den Veränderungen zugrunde liegende Ursachen sowie Hindernisse und fördernden Faktoren für den Konsum. Zu diesem Zweck wurden in drei Gemeinden Atakoras gezielt Personen der Landbevölkerung und Fachleute aus den Bereichen Landwirtschaft, Gesundheit und Ernährung in 42 semi-strukturierten Interviews mit lokalen und Fachexperten und 12 Fokusgruppen befragt. Die Ergebnisse zeigten, dass der Konsumtrend der untersuchten Pflanzenteile zunehmend (5 Pflanzenteile), rückläufig (5 Pflanzenteile) oder uneindeutig (6 Pflanzenteile) war. Alle Pflanzenteile wurden primär aus der natürlichen Umgebung erworben, ergänzt durch marktbasierte Transfers. Ursächlich für die unterschiedlichen Konsumtrends waren veränderte Zugänglichkeit, Erschwinglichkeit, Bequemlichkeit und Erwünschtheit der Pflanzenteile. Zum vermehrten Konsum hatten alle Pflanzenteile Barrieren in ihrer Zugänglichkeit und Erwünschtheit, während für einige, die Dimensionen Erschwinglichkeit und Bequemlichkeit keine hinderlichen Aspekte aufwiesen. Anstatt sich nur auf individuelle Verhaltensweisen der lokalen Bevölkerung und auf wissensbasierte Interventionen zu konzentrieren, kann eine ganzheitliche Sicht auf die einschränkenden und fördernden Kontexte, in denen Menschen ihre Nahrungswahl treffen, dazu beitragen, die Potenziale vernachlässigter Pflanzenarten für die Ernährung stärker auszuschöpfen.

Abstract

Julen, Lynn Carole. 2020. The personal food environment and its influences on the consumption of neglected and underutilised plant species in the region of Atacora (northern Benin), Master thesis at the University of Natural Resources and Life Sciences Vienna (Austria).

Although the African continent is considered as the most diverse region in the world in terms of wild and cultivated foods, especially Sub-Saharan Africa remains the world's most food insecure region. Regarding the requirements for healthy and nutritious diets, the potentials of many edible plant species remain unexploited. To better understand the influences of the personal food environment on consumption of neglected and underutilised species in the department of Atacora in northern Benin, this study investigated the changes in consumption of 16 plant parts (leaves, fruit pulps and seeds) of 11 species and their underlying drivers, as well as current barriers and enhancing factors for consumption. For this purpose, rural people and employees working in the fields of agriculture, health and nutrition were interviewed in 42 semi-structured interviews with local and professional experts and 12 focus group discussions in three communes of the Atacora department. The results showed that the consumption trend of the plant parts studied was increasing (5 plant parts), decreasing (5 plant parts) or ambiguous (6 plant parts). All plant parts were primarily acquired from the natural environment (cultivation, wild collection), supplemented by market-based and non-monetary transfers. The different trends in consumption were caused by changes in the accessibility, affordability, convenience and desirability of the plant parts. Aspects of accessibility and desirability were barriers for all plant parts' increased consumption, while for some of them, affordability and convenience represented no impeding aspects. Instead of focusing solely on individual behaviours and on knowledge-related intervention points, a holistic view on the constraining and enabling contexts in which people make food choices must be adopted to better exploit the potentials of these species for health and nutrition.

Content

1. Introduction

Although the African continent is considered as the most diverse region in the world in terms of wild and cultivated foods (Plant Resources of Tropical Africa 2010), especially Sub-Saharan Africa remains the world's most food insecure region (FAO et al. 2019). In the West African country Benin, approximately one-third of children below five years suffer from chronic malnutrition (INSAE and ICF 2019) and micronutrient deficiencies are a major public health problem, particularly for women of childbearing age and their children (Alaofè et al. 2017). With regard to the requirements for healthy and nutritious diets, the potentials of many edible plant species remain unexploited (Azam-Ali 2010; Shackleton et al. 2009). The term neglected and underutilised species (NUS) refers to those species whose potential is not fully realised. NUS can have an unexploited potential for food and nutrition security (Ebert 2014; Bharucha and Pretty 2010; Chadare et al. 2018; Hunter et al. 2019; Penafiel et al. 2011; Padulosi 2013), but also for more sustainable and resilient agroecosystems (Ebert 2014; Chivenge et al. 2015; Padulosi et al. 2011), higher social welfare (Mayes et al. 2012; Padulosi et al. 2011; Oluwatayo and Ojo 2014; Ebert 2014; Padulosi 2013) including their function as socio-economic safety nets (van Andel 2006), the empowerment of marginalised groups as well as sociocultural benefits (Padulosi et al. 2011; Padulosi et al. 2015).

Despite their potentials, various geographical, agronomic, economic, and sociocultural aspects in food systems represent barriers for the consumption of NUS (Padulosi and Hoeschle-Zeledon 2004; Baldermann et al. 2016). The specialization to a narrow base of food species happened since the beginning of human history (Hunter et al. 2019), but in the last half century it came to an overreliance on a small number of crops with negative outcomes for the environment, social welfare of people and their nutrition and health (Khoury et al. 2014; Willett et al. 2019). Particularly in low-and-middle-income countries (LMIC), food systems and diets are undergoing major transformations driven by changes in agricultural systems, economic development, urbanisation, global trade, technology as well as social and cultural changes (Popkin 2015, 2004; Ericksen 2008). These changes led to a reduced diversity of food sources (Hunter et al. 2019) and a global homogenisation of diets (Khoury et al. 2014), associated with lower dietary quality (Popkin et al. 2020). Dietary patterns result from complex interactions of physical, biological, psychological, socioeconomic and sociocultural factors (Powell et al. 2015; Köster 2009; Sobal et al. 2014) and there is growing evidence that individual, knowledge-related factors are often less decisive in shaping food choices and consumption than previously assumed. Meanwhile the importance of contextual factors, which are beyond the individual consciousness and control, is increasingly recognised (Chadwick et al. 2013; Powell et al. 2017).

The construct of food environments at the interface of food systems and diets captures the scope of options people consider to acquire and consume foods (Turner et al. 2018). The personal food environment deals with how individuals perceive the accessibility, affordability, convenience and desirability of food products (Turner et al. 2018). In rural food environments of LMIC, food consumers are often also food producers and thus many foods are sourced within the local food system (Raneri et al. 2019). Particularly in lower income countries, more empirical investigations about what drives changing food environments and diets are needed (Turner et al. 2018; McMullin et al. 2019; Turner et al. 2020). A better understanding the contrasting and enabling contexts of consumption is key to inform further nutrition interventions with the aim to food and nutrition security, environmental security and to enhance livelihood assets (Kuhnlein and Pelto 1997; Padulosi et al. 2002).

The objective of this master thesis is to gain a better understanding of the personal food environment of selected NUS and therefore of their consumption from a historical and contemporary perspective in the region of Atacora in Northern Benin. This includes:

1. Assessment of the historical change in the consumption of neglected and underutilised species

2. Identification of dimensions of the personal food environment that relate to the historical change in the consumption of neglected and underutilised species
3. Identification of barriers and enhancing factors in the personal food environment for the consumption of neglected and underutilised species

Thus, the following research questions were formulated:

1. How did food consumption of neglected and underutilised species change?
2. How do the dimensions of the personal food environment explain the historical changes in food consumption of neglected and underutilised species?
3. How do the dimensions of the personal food environment influence the contemporary food consumption of neglected and underutilised species?

2. State of the art

2.1. Food systems and the role of neglected and underutilised species (NUS)

In the 21st century, food systems are characterised by environmental, economic and social change (Maxwell and Slater 2003). Globally, food supplies and diets became more similar in composition (Khoury et al. 2014; Schmidt et al. 2010). Most of the agricultural area worldwide (82%) is used to grow 20 major plant commodities (Schmidt et al. 2010) and four staple crops (rice, wheat, maize, and potato) provide the majority of the world's energy needs (Padulosi et al. 2002; Fanzo et al. 2013). Despite this narrow range of plant species which are produced and consumed, it is estimated that approximately 400'000 known plant species exist worldwide (Christenhusz and Byng 2016). Throughout history, only a part of these species have either been cultivated or collected as food (Garn and Leonard 1989). Estimates vary in the range of 5'000-10'000 edible plant species (Wiersema et al. 1999; Williams and Haq 2002; Royal Botanic Gardens Kew 2016). Many of these species lost their former importance for food consumption in specific regions (Padulosi and Hoeschle-Zeledon 2004). Thus, there are thousands of species with possibly untapped potentials contributing to food and nutrition security, social welfare and environmental services, which fall under the collective term NUS (Hawtin 2007). A species can be underutilised from an economic, geographical, social or temporal perspective (Baldermann et al. 2016; Dansi et al. 2012; Chivenge et al. 2015; Padulosi et al. 2002) and neglected by the low level of attention obtained from research and conservation (Padulosi et al. 2002). Both cultivated plant species, which in this case are called neglected and underutilised crops species (NUCS) as well as wild edible plants can be covered by the term NUS (Padulosi and Hoeschle-Zeledon 2004). NUS are not mandatorily restricted to specific localities or regions, but can be distributed beyond their centres of origin (Padulosi et al. 2002). What these species have in common is their association with local production and consumption systems (Shackleton et al. 2009).

To better understand what led to the decreased species' diversity used in today's food systems, the drivers and outcomes of food systems and the difficulties and potentials of NUS along the food systems' activities are discussed in the following subchapters.

2.1.1. Drivers, activities and outcomes of food systems

Food systems contain of interactions between the bio-geophysical and socioeconomic environments as well as the outcomes of those activities contributing to food security, social welfare and environmental security (Figure 1) (Ericksen 2008). They encompass all stakeholders and their interlinked value-adding activities ranging from production, processing and storage, trade and retail to consumption and disposal of food products, the resources used for food products as well as the broader economic, societal and natural environments in which they are embedded (FAO et al. 2019).

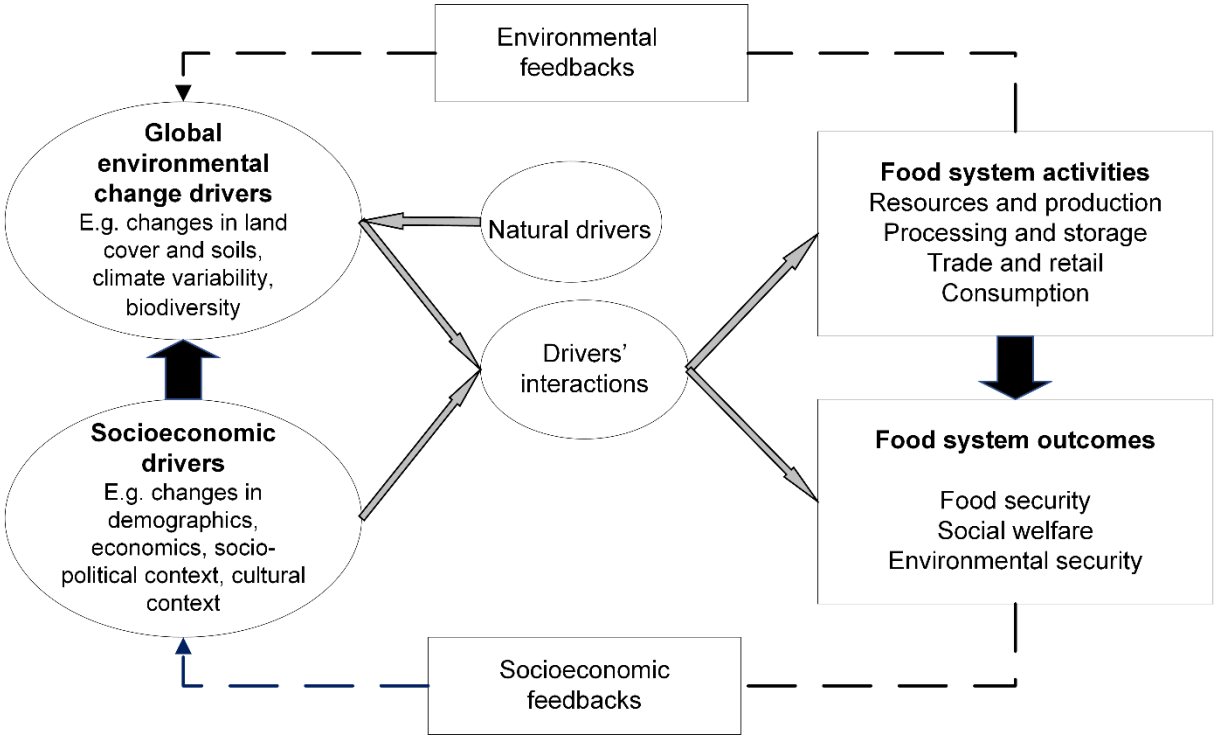


Figure 1 Food system drivers, activities and outcomes (source: simplified presentation according to Ericksen 2008)

Interacting environmental and socioeconomic elements drive transformations in food systems' activities and outcomes. Global environmental change drivers include shifts in land cover and soils, climate variability, water availability and quality, nutrient availability and cycling and biodiversity. Socioeconomic drivers comprise of changes in demographics, economics, socio-political contexts, sociocultural contexts, science and technology (Ericksen 2008). Regarding specific value chain activities, in resources and production, the promotion of high-input and high-yielding crop species, with the intensification of a limited number of species causes a decline in crop diversity in agricultural systems across the world (Chivenge et al. 2015). Moreover, production becomes replaced in importance by downstream value-adding activities within the transformation from traditional to more modern food systems (Maxwell and Slater 2003). These activities, primarily trade and retail, are increasingly affected by the expansion of global trade (Popkin 2015) in which transnational food companies control global and domestic food markets, increase competition and create cultural identifies for different foods (Hawkes 2006). Changes in consumption include trends towards higher intakes of processed foods and animal proteins (Maxwell and Slater 2003; Popkin 2015, 2004).

The principal outcome of food systems contains of the food security status of any group or individual (Ericksen 2008). Although globally, the agricultural system produces enough food, access to sufficient affordable and nutritious food remains challenging (Fanzo et al. 2013; Willett et al. 2019; Bailey 2016). Food security is defined as "a situation that exists when all people, at all times, have physical, social and economic access to sufficient, safe and nutritious food that meets their dietary needs and food preferences for an active and healthy life" (FAO et al. 2019, p. 186). Associations between food insecurity and malnutrition can take various forms (Maitra 2018). Malnutrition refers to "an abnormal physiological condition caused by inadequate, unbalanced or excessive consumption of macronutrients and/or micronutrients" (FAO et al. 2019, p. 188). It includes undernutrition (stunting, wasting and micronutrient deficiencies) as well as overnutrition (overweight and obesity). Different types of malnutrition can interact with each other and simultaneously occur at the community, household and individual level (Popkin et al. 2020; FAO et al. 2019).

In today's food systems, many interlinked causes at different levels result in food insecurity and malnutrition. Basic causes include inadequate financial and human capital, access to services as well as sociocultural, economic and political contexts (UNICEF 2013). Most Sub-Saharan African countries are characterised as food insecure and many LMIC increasingly face the double-burden of malnutrition (FAO et al. 2019). A lack of diversification in production and consumption can lead to less healthy and nutritious diets as the dietary diversity is strongly associated with the nutritional status (Arimond and Ruel 2004). The low quality of diets is a principal cause for malnutrition (Hunter et al. 2019), with insufficient consumption of fruits, vegetables, legumes, nuts and whole grains, particularly in Sub-Sahara Africa (McMullin et al. 2019; Keatinge et al. 2010).

2.1.2. Difficulties and potentials of NUS along food systems' activities

There are different reasons for the dominance of global food systems by a few crops in detriment of the wealth of agrobiodiversity to which NUS belong. Agronomic, economic, geographical, temporal and sociocultural constraints contribute to the decline respectively everlasting low level of consumption of NUS (Padulosi and Hoeschle-Zeledon 2004; Baldermann et al. 2016).

In the following, difficulties and potentials of NUS are described along the food systems' activities.

2.1.2.1. Resources and production

The first food supply value chain element involves all activities involved in production of raw food materials (Ericksen 2008). Agroecological barriers like climate, nature, soils, presence and collection of waters determine agricultural cultivation possibilities (Bricas 1998). Many NUS are only cultivated at subsistence level and are bound to local conditions (Chivenge et al. 2015; Hawtin 2007). In comparison with major crops, the competitiveness of NUS is often lower because they are less supported by innovations. Moreover, NUS have low or no formal food supply systems (Padulosi and Hoeschle-Zeledon 2004), farmers are financially limited in production means (Bricas 1998) and the cultivation of NUS is often linked to labour-intense work (Boedecker et al. 2014; Hawtin 2007). Consequently, the availability of NUS is often limited (Baldermann et al. 2016).

Despite their constraints, NUS contribute to the wealth of agrobiodiversity and more stable ecosystems (Jaenicke and Höschle-Zeledon 2006; Hawtin 2007). In terms of production systems, they have the potential for more diverse cultivation and rotation systems with less external inputs required. Many NUS are for instance less susceptible to diseases in small-scale or mixed cropping systems (Hughes and Ebert 2011) and tend to be adapted to specific agroecological niches, such as harsh environmental conditions on marginal lands. Thus, they are often more resistant to biotic and abiotic stresses (Chivenge et al. 2015). These characteristics become increasingly important regarding the limited availability of arable land (Baldermann et al. 2016) and impacts of climate change including extreme weather events (Padulosi et al. 2011). The high adaptation capacity and the diversity of uses of NUS indicates their historically important role in rural communes (Chivenge et al. 2015). Smallholders produce approximately a third of the food supply (Ricciardi et al. 2018) and have particular knowledge on specific plant species and their biological and ecological properties (Baldermann et al. 2016; Pilgrim et al. 2008).

2.1.2.2. Processing and storage

Processing and storage include the various ways of transformation of raw food materials. These value-adding activities can change food products' properties such as their appearance, nutrition values or storage life (Ericksen 2008). Barriers include specific plant properties (e.g. bitterness, hard seed coats) (Padulosi et al. 2011), limited possibilities for processing to ensure quality standards due technological constraints in monitoring processing parameters and poor

storage (Baldermann et al. 2016; Hawtin 2007). The high-water content makes most fruits and vegetables highly perishable. Subsistence farmers might lack resources for modern storage techniques such as cooling devices or know-how how to apply available techniques. This can diminish the quantity and quality of foods (Baldermann et al. 2016).

On the other hand, the transformation of foods can reduce specific plant properties such as anti-nutritional components (Padulosi and Hoeschle-Zeledon 2004), while enhancing the bio-availability of nutritious compounds, increasing the market value and extending shelf-life (Baldermann et al. 2016). Shelf-life and quality can for instance be improved through low-cost storage methods such as air-drying, solar-drying or fermentation (Baldermann et al. 2016).

2.1.2.3. Trade and retail

Trading and retailing activities refer to movements of food products with the purpose of their sale. Trading and retailing rely on issues such as transportation, infrastructure, trade regulations and advertisements (Ericksen 2008). In rural areas, trade and retail of NUS are generally on a low level as many people depend on self-sufficiency (van Andel 2006). Furthermore, NUS are often marginalized by policy makers (Padulosi 2013). Limited market opportunities and low market prices can contribute to the designation of NUS (Mayes et al. 2012). Extrinsic properties such as price, colour, packaging of NUS influence their attractivity for purchase. There is an increased need for market strategies which meet consumers' demands (Baldermann et al. 2016).

Many NUS provide an alternative source of micro- and macronutrients compared to often less affordable animal-based products (Baldermann et al. 2016). They can also represent a source of livelihood and cash income (Oluwatayo and Ojo 2014) and can function as an economic and dietary safety net (van Andel 2006) for instance in periods of food shortage (van Liere et al. 1995; Guin and Lemessa 2000; Cook et al. 1998; Boedecker et al. 2014; Savy et al. 2006). Political and economic frameworks which recognise the importance of NUS can incentivise their consumption (Hunter et al. 2019).

2.1.2.4. Consumption

Consumption involves food selection, acquirement, preparation, intake and digestion (Ericksen 2008). Habits, cultural perceptions and attitudes can hinder or limit people to fully exploit wild species collection and trading (Fentahun and Hager 2009). Attributions of NUS as "low status food" occur over all regions and cultures (Padulosi et al. 2011). Lack of knowledge or ignorance of the value of NUS, wild species' free availability, increasing demand for convenience food are possible explanatory factors (Fentahun and Hager 2009). Furthermore, low sensory preferences, low awareness of NUS' beneficial effects for health and nutrition as well as insufficient knowledge and skills about processing and preparation techniques can impede their consumption (Baldermann et al. 2016).

Many NUS offer an important source of micronutrients, vitamins and secondary plant metabolites, especially in rural households in which farming is the main source of food and income (Baldermann et al. 2016). Further functions consist of providing pleasure or helping to maintain social traditions (Padulosi et al. 2019) as NUS are linked to cultural identity (Padulosi et al. 2011). Sometimes reconnection with traditional values represent an important element for their rediscovery and enhanced consumption. Consumers' acceptance and preferences can increase through awareness raising activities such as advertising and media stories (Baldermann et al. 2016).

2.1.3. Research gaps

Food systems and diets are undergoing rapid changes (Wahlqvist and Lee 2007) and their drivers and outcomes need to be understood from a holistic, systemic perspective. Coupled socio-ecological drivers are interacting at different scales and need more empirical

investigations such as case studies to identify critical drivers and processes (Ericksen 2008). Although increased awareness of the role of NUS for food security, human wellbeing and ecological ecosystem services has been noticed, a better understanding on the reasons which prevent or decrease the use-level of NUS is needed (Padulosi et al. 2002; Padulosi et al. 2011). In this context should changes in diets, threats and barriers to NUS as well as the vulnerability of people not only be seen from a physical angle, but include a sociocultural perspective (Lang and Rayner 2007). The various sociocultural and economic factors that might influence the use of wild and cultivated biodiversity need to be better understood (Powell et al. 2015). NUS play different roles in different contexts. Whereas in some regions or cultures, they might have been neglected and replaced by other species, they play an essential role in others (Bvenura and Sivakumar 2017). Particularly in LMIC, little is documented about what drives food choices and consumption of NUS (McMullin et al. 2019; Kuhnlein and Receveur 1996).

2.2. Approaches to food choices and consumption

Food choices and consumption both include decisions about acquisition, preparation, transformation, service and food intake and disposal of food (Sobal and Bisogni 2009; Warde 2005; Neuman 2019). They are analysed under multiple, fragmented perspectives (Doucerain and Fellows 2012) with few interdisciplinary approaches (Köster 2009). Different disciplines such as nutritional science, food science and technology, psychology, neuroscience, sociology, business research deal with at least one part of the central question in food choice research ‘‘Why does who eat what, when, and where?” (Köster 2009, p. 70).

Among the various theoretical perspectives to food choices and consumption, three metatheories are distinguished: rationalism, structurism and constructionism. From the rationalist perspective, social behaviour is guided by cost and profit considerations. This implies conscious, rational selection and analyses eating as “food-related decision-making” (Sobal et al. 2014; Sobal and Bisogni 2009). A second approach follows a structuralist approach (Sobal and Bisogni 2009), from which food choices and consumption rely on social structures. Differences in dietary practices are not only an outcome of income differences, but also related to cultural differences and social distinctions (Charles and Kerr 1988). The third constructionist approach considers both individual and structural factors (Sobal and Bisogni 2009).

These three approaches to food choices and consumption are explained in the following subchapters.

2.2.1. Rationalist approaches

In rationalist approaches, decision-making is based on a cognitive process of rational calculation. Key concepts include attitudes, behaviours, conscious choice, and rational action. The unit of analysis are individuals (Jaccard and Wood 1986). Based on the theory of planned behaviour (Ajzen 1991), behaviour depends on attitudes which are formed by behavioural, cognitive and emotional components (Rosenberg and Hovland 1960). Attitudes describe the systems of thoughts and actions, learned associations and emotional aspects towards both concrete and abstracts objects, sensory qualities etc which are guiding individuals’ behaviours (Olsen 1999). Several food choice concepts are part of behaviour approaches. One concept represents the hierarchical value-attitude-behaviour-model (Homer and Kahle 1998) or the food choice model by Shepherd 1985. The latter provides an extension of the basic model of theory of planned behaviour and distinguishes between three factors, consumer related, food-related and environmentally related factors (Shepherd 2001; Wądołowska et al. 2008; Shepherd 1999). Another concept, the behavioural alternative model (Jaccard and Wood 1986), considers the attitude towards a variety of food and explains choices among a variety of food alternatives. Preference structures and perceptions toward the food alternatives guide the decision-making process (Brinberg and Axelson 1990).

Several assumptions are underlying these approaches including full information available about all relevant criteria and viable alternatives for decision-making as well as clear and constant preferences. However, these assumptions are not realistic, because incomplete information, uncertainty about consequences, consideration of other aspects than costs and benefits, non-individualised decisions etc. take place in decision-making (Sobal and Bisogni 2009). Gaps between attitudes and actual behaviour are often stated. Changes in values and attitudes do not lead automatically to changed consumer behaviour (Southerton 2013) and past behaviours are better predictors of future actions than attitudes and intentions (Köster 2009).

2.2.2. Structuralist approaches

From a structuralist approach, social institutions and other environments are key determinants for individual decision-making. These institutions provide values and norms. On the macrolevel, structures like societies, cultures and markets constrain the individual's potential decisions and provide the context within they happen (Sobal and Bisogni 2009). The individual's agency, which refers to the capacity of a person to act in any given environment, is therefore restricted by these structural conditions. Approaches from such a perspective analyse how food choices are made within their social, cultural, political economic and geographical contexts (Reckwitz 2002). Whereas some approaches sharply distinguish between biological, physiological, psychological, situational, sociocultural etc. factors (Köster 2009), others state, that all aspects of food choices and eating are embedded in a sociocultural context (Rozin 1996). However, the influence of culture and society on food preferences and choices is rooted in a combination of factors emerging from the physical and social environment, of ritual and belief systems, of human endeavour, degree of mobility, economic and political sphere as well as sociodemographic traits of individuals (Mela 1999; Vabø and Hansen 2014; Wright et al. 2001).

Although these approaches consider the importance of societal influences on people's decision-making, they only focus on certain constraining aspects in which food choices occur (Sobal and Bisogni 2009). It is indeed the case that subjects actively interact with their surrounding environment and food choices are mostly unconscious practices in daily life (Palojoki and Tuomi-Gröhn 2001). Rationalist and structuralist approaches both dismiss the unconscious layer of knowledge which plays an important role in food choices (Reckwitz 2002).

2.2.3. Constructionist approaches

Constructivist approaches perceive decision-making processes as socially constructed. Individuals actively conceptualize, interpret, and negotiate their options. Such constructionist approaches include both the macro- and micro-level in terms of structure and agency, which interact and construct decisions (Archer 1998). They include theories of constructivism, symbolic interactionism, and many others (Sobal and Bisogni 2009). Models which can be assigned to constructionist approaches are the food choice process model (Furst et al. 1996), or practice theory approaches (Halkier and Jensen 2011). The concepts assigned to the constructionist approach indicate that many food choices and consumption patterns have little to do with the actual physiology, nutritional value or physical properties of food (Furst et al. 1996). Food choices also cannot be fully explained by relatively stable concepts such as lifestyle, but they should be seen as dynamic and relational actions (Halkier and Jensen 2011).

The holistic perspective applied in the food choice process model moves beyond individual characteristics to collective and contextual factors. Construction of food choices include people's rules and routines for eating, their prioritisation and negotiation of values (Sobal and Bisogni 2009). Similar to the food choice process model, in practice theory approaches, many consumption processes, such as grocery shopping and eating, are seen as routinised, quotidian and unremarkable (O'Neill et al. 2019; Neuman 2019; Reckwitz 2002). They are positioned in between structuralist and individual-centred approaches (Røpke 2009) and practices are instead of individuals or structures the main agent (Halkier and Jensen 2011). Environmental

and social conditions as well as shared meanings such as norms and conventions shape dietary habits (Holm 2016). Food consumption behaviours usually evolve in a close social environment such as the family context and are relatively stable over time (Delormier et al. 2009). They are embedded in social relations which are structured by class, ethnic group affiliation, institutional practices, and other factors and create social identity and group affiliation (Poland et al. 2006).

2.2.4. Research gaps

The trans- and interdisciplinary field of food studies lacks unified theories (Neuman 2019). Most food choice approaches' primacy remains individual choice (Palojoki and Tuomi-Gröhn 2001; Warde 2016) and they reduce food choices to consumer behaviour and shopping decisions or to their outcomes in terms dietary intake per person (Palojoki and Tuomi-Gröhn 2001; Neuman 2019; Warde 2005). Thus, food choices are often analysed under single, measurable factors, although most decisions are neither merely rational, nor can they be explained by solely personal factors. There is growing evidence, that habits and contextual factors shape dietary choices, whereas conscious awareness and knowledge are often less decisive (Chadwick et al., 2013). Thus, food choices consist of complex behaviours with interrelated drivers (Palojoki and Tuomi-Gröhn 2001). With a main research focus on food habits in Western countries (Mintz and Du Bois 2002), factors such as necessity and traditions are less considered (Frewer and van Trijp 2006). Notwithstanding, it is essential to understand roles, norms, communication networks and decision-making patterns in specific household and commune settings. Especially in non-Western societies, attitudes and practices related to nutrition and health are influenced by wider social networks such as multigenerational relations. Therefore, non-western patterns of practices, social structures, organisations and normative systems need to be taken into account (Aubel 2012).

2.3. Food environments

The bi-directional relationship between food choices and food systems is represented by the concept of food environments (Figure 2). "The food environment is the interface that mediates people's food acquisition and consumption within the wider food system" (Turner et al. 2018, p. 95). Food systems are shaped by food choices and consumption, as consumer demand affects what kind of foods are produced, transformed and eaten. Food systems in turn influence the decisions of consumers by defining possible options (Grace 2016). The distinction into an external and internal domain of the food environment emphasizes that multiple interlinked, structural and individual factors shape people's consumption. The external domain refers to the given opportunities and constraints under which acquisition and consumption take place. This "objective reality" encompasses aspects of availability, prices, vendor and product properties and marketing and regulations. The personal domain includes individual perceptions of how accessible, affordable, convenient, and desirable foods are. Interactions between these domains and dimensions shape people's food acquisition and consumption (Turner et al. 2018).

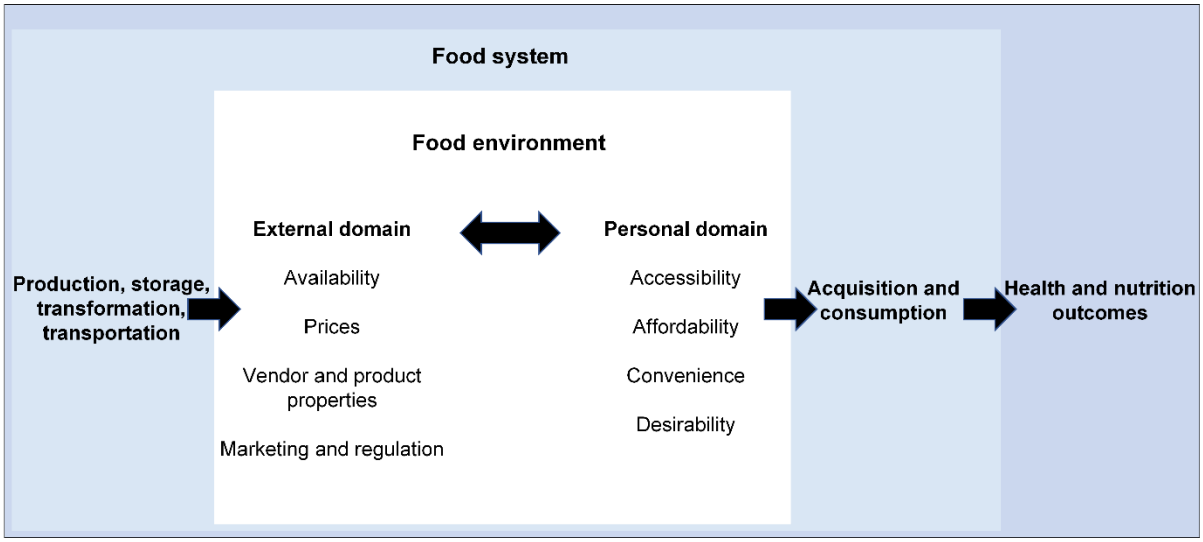


Figure 2 The conceptualization of food environment as the interface with the wider food system and consumption (simplified representation according to Turner et al. 2018)

2.3.1. External and personal domains of food environments

Within food systems, food can be acquired from built and natural environments. Particularly in LMIC, natural and built food environments often co-exist as people acquire their food from market-based transfers (formal and informal markets), non-monetary transfers (in-kind transfers and gifts), from own cultivation and wild collection (Turner et al. 2018). The acquisition from these different sources and consumption result from the interactions of the dimensions of the external and internal domains, which are outlined in the following subchapters.

2.3.1.1. Availability - accessibility

Firstly, the food environment concept distinguishes between the availability as external and accessibility as personal dimension of the food environment. Availability refers to the presence or absence of a food source or product within a given context and always presupposes accessibility. To clarify between physical and other forms of access such as economic or social one, the term accessibility only refers to physical distance, time- and transport-based aspects relative to individuals (Turner et al. 2018).

2.3.1.2. Prices - affordability

The second dimension of the external food environment domain includes the monetary value of food products, reflected by their prices. The personal domain refers to the individually perceived affordability which determines the economic access to food sources (Turner et al. 2018).

2.3.1.3. Vendors and products properties - convenience

The third distinction includes the external dimension of vendors and products properties and the personal dimension of convenience. Vendor properties refer to the conditions under which products are sold and product properties include aspects such as food quality, level of processing and storage possibilities (Turner et al. 2018). Convenience deals with the immediate availability of food products and includes aspects such as shelf-life and preparation time (Nestle et al. 1998). Individual time allocation and preparation facilities determine the level of convenience (Turner et al. 2018).

2.3.1.4. Marketing and regulation - desirability

The fourth category comprises of external marketing and regulation, and personal aspects of desirability. Marketing includes all promotional activities regarding food products, whereas regulations include formal, legal frameworks of food sales. Within the personal domain, individual preferences, acceptability, tastes, desires, attitudes, culture, knowledge and skills shape the desirability of food vendors and products (Turner et al. 2018). Aspects which fall under the category of desirability can in turn be divided into internal and external aspects such as taste (internal aspect), status of foods, cultural norms, advertising, product placement, food quality (external aspects) (Herforth and Ahmed 2015).

2.3.2. Empirical findings of the personal food environment in Sub-Sahara Africa

To better understand the influences of the personal food environment on NUS consumption, empirical findings with focus on the Sub-Saharan African context were identified and categorised after the four key-dimensions accessibility, affordability, convenience and desirability.

2.3.2.1. Accessibility

Accessibility represents a major challenge for NUS consumption in Sub-Saharan Africa (Bvenura and Sivakumar 2017). The availability of land and agronomic characteristics can influence the accessibility of cultivated and wild species. In a study in Benin, low soil fertility and yields, susceptibility to pest and diseases, weeds and high soil moisture as well as lack of improved cultural practices and varieties are negatively influencing the use of cultivated species (Dansi et al. 2012). The unavailability of agricultural land is identified as an important driver for dependence on forest resources in the Atacora region in Northern Benin (Vodouhê et al. 2009). Besides physical aspects, seasonality is a key element of accessibility (Savy et al. 2006). Specific temporal patterns influence for instance the use of wild edible plants (Avohou et al. 2012). Whereas herbs have often a limited availability during rainy season, products of multipurpose woody species are accessible for a longer period (Vodouhê et al. 2009). Particularly in periods of food shortage, NUS are an important source for nutrition (van Liere et al. 1995; Guin and Lemessa 2000; Cook et al. 1998; Boedecker et al. 2014; Savy et al. 2006).

2.3.2.2. Affordability

The lack of organised markets is the most frequently mentioned barrier by farmers for the consumption of cultivated NUS in Benin. In addition, low profitability of production systems are restricting the consumption of crops from an economic perspective (Dansi et al. 2012). This is also shown by the fact that the choices of perennial species in agroforestry systems co-depend on cost-benefits considerations like their commercialisation and income generating levels (Assogbadjo et al. 2012). Besides lacking or low marketing possibilities, widened access to markets can reduce the consumption of NUS (Bharucha and Pretty 2010). Use patterns can a for instance change in the way that edible plants are increasingly sold in markets to earn cash rather than for self-consumption (Thakur et al. 2017).

2.3.2.3. Convenience

Cultivation and post-harvest activities of NUS are linked to labour-intense work (Dansi et al. 2012), or long cooking times (Boedecker et al. 2014). Such convenience-related aspects like the ease of preparation in terms of time, the level of giving soups a slimy consistency and the compatibility with starchy foods are mentioned as important preference criteria for leafy vegetables in Benin (Dansi et al. 2008). Another study in South Africa indicates that convenience in terms of preparation time and effort was not an important driver for consumption of indigenous and traditional food crops (Cloete and Idsardi 2013).

2.3.2.4. Desirability

Besides physical, economic, and temporal resources, sociocultural aspects influence consumption. Several studies in the Sub-Saharan context confirm that traditions, beliefs, taboos, knowledge and sensory preferences shape consumption patterns (Guin and Lemessa 2000; Dansi et al. 2008; Aubel 2012; Achigan–Dako et al. 2010). They indicate that ownership structures and work roles co-determine acquisition and consumption of plant species (Avohou et al. 2012; Alonso et al. 2018; Lokonon et al. 2018). In Benin, particularly women's access to land and its resources depends on men-based, while women are often in charge of harvesting, processing and selling (Lokonon et al. 2018; Avohou et al. 2012). Intra-households dynamics further influence individual access to food (Alonso et al. 2018). Women and the elderly are often so-called nutritional gatekeepers who influence the diets' composition and distribution of other household members (Kuhnlein et al. 2013). In a Senegalese study for instance, older women are transmitting sociocultural norms about nutrition (Aubel 2012). Specific cultural beliefs and taboos can further influence consumption patterns. Taboos are assumed to play an important role in cultures or ethnic groups in Benin, where animism is developed (Dansi et al. 2008). Farmers in Benin mention that sociocultural barriers in form of cultural beliefs have a negative impact on production of specific NUCS (Dansi et al. 2012).

Differences in power relations and households' organisation can influence how species are valued. For instance, women value food species higher, whereas men give higher values for medicinal species and species used for construction work (Vodouhê et al. 2009). Generally, high social values of foods can become visible in celebratory events or other specific occasions in which specific foods are prepared (Edame et al. 2011). The influence of the social values assigned to foods remains varied. A study indicates that the consumption of wild fruits and vegetables are determined by their image (Matenge et al. 2012), whereas others indicate that the image of a species represented no major driver for consumption (Boedecker et al. 2014; Cloete and Idsardi 2013).

Use patterns of traditional species are furthermore linked to indigenous knowledge (Dansi et al. 2008; Lokonon et al. 2018; Avohou et al. 2012). Knowledge of the biology and ecology of the species, including propagation and seed storage methods influence the management practices of wild edible plants in Central Benin (Avohou et al. 2012). Knowledge about non-timber forest products is a significant predictor for food-related uses, accumulating with age. Elderly people have in some contexts more knowledge about food plants (Lokonon et al. 2018), whereas in others, the category of people under 30 years have the most knowledge of wild fruits (Fentahun and Hager 2009). The findings that knowledge increases with age can be explained by the assumption that knowledge accumulates over people's lifespan (Brandt et al. 2013; Hanazaki et al. 2013) or that elderly people are less exposed to external factors (Quinlan and Quinlan 2007). Besides knowledge and skills regarding the acquisition of food, post-harvest related aspects such as familiarity, preparation knowledge and skills and health awareness level can determine consumption. The importance of health and nutrition as the most enhancing factor for consumption of indigenous and traditional foods is highlighted by rural and urban respondents in South Africa. At the same time, the lack of knowledge and skills in food preparation and nutrition information are identified as barriers for their consumption, especially for younger respondents (aged 20-40) (Matenge et al. 2012). Another study confirms that unfamiliarity with traditional plants represents a major barrier for their consumption (Cloete and Idsardi 2013).

Consumption pattens of plant species are further influenced by sensory preferences whose importance in lowering or enhancing consumption are confirmed by several studies in the Sub-Saharan African context (Bvenura and Sivakumar 2017; Achigan–Dako et al. 2010; Thakur et al. 2017; Cloete and Idsardi 2013; Matenge et al. 2012). A review of fruit and vegetable consumption in Sub-Saharan Africa shows that exotic fruits and vegetables might surpass endemic ones in their sweet taste and colour (Bvenura and Sivakumar 2017).

2.3.3. Research gaps

Food environments in LMIC are still a relatively little studied area. A review shows, that the majority (70%) of studies on food environments takes place in upper-middle-income countries, 26% in lower-middle income countries and none in low-income countries (Turner et al. 2020). Moreover, most studies focused on the built food environment although in many contexts the natural environment is of particular importance for the acquisition of food at the household level (FAO et al. 2019). Also, the personal domain of food environments, particularly the dimensions of affordability, convenience and desirability, remain understudied compared to the external dimensions. Although there are still few stakeholder-based approaches which combine multiple qualitative methods, the need to understand these personal dimensions is increasingly recognised (Turner et al. 2020). Thus, more holistic approaches need to encompass all different food sources (market-based, own production, wild harvest and transfers) in different contexts (Herforth and Ahmed 2015) as well as qualitative aspects of food environments, predominantly in LMIC (Turner et al. 2020).

3. Conceptual framework

The concept of the personal food environment provides the basic structure for analysing the options people consider for the consumption of selected NUS in this thesis. The four key-dimensions accessibility, affordability, convenience, and desirability of the personal food environment shape changes in diets over time as well as current consumption patterns (Turner et al. 2018). Whereas the first three dimensions are well defined, the fourth dimension of desirability lacks conceptualisation (Ahmed et al. 2018). Theoretical approaches to food systems and choices as well as empirical findings of the desirability of NUS in the Sub-Saharan Africa context complement this dimension. Holistic food system approaches consider all value chain elements from production to consumption as well as knowledge and sociocultural practices related to them (Kuhnlein et al. 2009; Ericksen 2008). Furthermore, constructionist approaches on food choices move beyond solely biological or individualist-rational thinking (Sobal et al., 2014), but indicate that food choices are embedded in a mutual relationship within a wider political, economic, legal and sociocultural framework (Røpke 2009). Thus, these approaches provide insights on how interrelated personal and environmental aspects shape the desirability of food, whereby the following aspects are included: informal institutions, social markers, biological and ecological knowledge and skills, food and nutrition knowledge and skills as well as preferences for sensory properties (Table 1).

Table 1 Conceptual framework of the personal food environment influencing the consumption of NUS

Dimension	**Definition**	**Example**
Accessibility	Physical distance, time- and transport-based aspects relative to individuals (Turner et al. 2018)	Physical distance to overcome to consume X
Affordability	Purchasing power (Turner et al. 2018)	Level of sale of X
Convenience	Relative time and effort (Turner et al. 2018)	Workload to consume X
Aspects of desirability		
Informal institutions	Norms of behaviours, conventions and self-impose codes of conducts (Berkes 2004)	Work roles regarding consumption of X
Social markers	Social status and group membership (Pollard 2002)	Attribution of X as "food for the poor"
Ecological and biological knowledge and skills	Knowledge on phenology, propagation modes and seed storage methods (Avohou et al. 2012; Gandji et al. 2018) and about the relationship between humans, animals, plants, and the physical elements of their environment as well as related management (Berkes 2008)	Knowledge about maintenance measures for X
Food and nutrition knowledge and skills	Attributes related to facts and information acquired through experience or education related to foods and nutrition as well as techniques of food purchasing, preparation, handling and storage (Azevedo Perry et al. 2017)	Perceived nutritional value of X
Preferences for sensory properties	Sensory responses to visual appeal, aroma, taste, and texture (Herforth und Ahmed 2015)	Taste preferences for X
Additional factors	Factors which cannot be assigned to one of the existing factos and which influence consumption	

4. Methods

4.1. Overview

A qualitative approach offers the potential to provide an in-depth understanding of the personal food environment influencing the consumption of the selected NUS. The personal dimensions and aspects which shape consumption can be measured through stakeholder-based approaches such as qualitative interviews (Turner et al. 2018). A purposive sampling was applied to select the interview partners in three communes of the department of Atacora in northern Benin. Empirical data was collected through semi-structured interviews and focus group discussions during October and November 2019. The experts for the semi-structured interviews were selected with the aim to obtain specific information in terms of subjective views, interpretations and explanation patterns of the selected NUS' food environment (Albuquerque et al. 2014). The focus groups participants were sampled to depict different profiles of the rural population in the research area and whose discussions allowed to get different opinions, feelings and perceptions (Krueger and Casey 2014). Collected data was translated (in case of the interviews in local languages) and transcribed to French and analysed by qualitative content analysis.

The overview of the methodological structure of the study (Table 2) is followed by the presentation of the project background and the selected NUS, research region, sampling, data collection and analysis.

Table 2 Overview of methods

Research questions	**Sampling**		**Data collection**	**Data analysis**
1. How did food consumption of NUS change?	Purposive sampling	Local experts (n=24): Elderly commune members with a long-lasting life history in the three selected communes of Atacora	Semi-structured interviews	Qualitative content analysis
2. How do the dimensions of the personal food environment explain the historical changes in food consumption of NUS?		Professional experts (n=18): Stakeholders working in the agriculture, health and nutrition sector in the three selected communes of Atacora		
3. How do the dimensions of the personal food environment influence the contemporary food consumption of NUS?		Focus groups (n=12): Members of six villages in the three selected communes of Atacora	Focus group discussions	

4.2. Study background and the selected NUS

This thesis is part of a research project called "Enhancing consumer demand and uptake of nutritious underutilised plant species in the region northern Benin". The research activities focus on the eleven selected NUS: *Adansonia digitata* L., *Balanites aegyptiaca* (L.) Delile, *Blighia sapida* K.D. Koenig, *Cleome gynandra* L., *Detarium microcarpum* Guill. & Perr., *Hibiscus*

sabdariffa L., *Moringa oleifera* Lam., *Ocimum gratissimum* L., *Parkia biglobosa* (Jacq.) R.Br. ex G.Don, *Tamarindus indica* L. and *Vigna radiata* (L.) R. Wilczek.

4.2.1. Research project

As part of the GIZ's One World – No Hunger (OWNH initiative program entitled "Food and Nutritional Security - Enhanced Resilience (FNS-ER)", this project aims to increase consumer awareness of the nutritional potential of underutilised edible plant species in the Atacora region and increase the motivation to include these species into local people's diets. The project is conducted by the Alliance of Bioversity International and the International Center for Tropical Agriculture (CIAT) in collaboration with GIZ within the "Global Programme on Food and Nutrition Security, Enhanced Resilience" (ProSAR), the French Research Institute for Sustainable Development (IRD), the Faculty of Agricultural Sciences of the University of Abomey-Calavi (FSA/UAC), the University of Göttingen (Germany) and the University of Hohenheim (Germany). Besides the sociocultural aspects of consumption of the selected NUS, which are investigated in this study, further investigations analyse the ethnobotanic, agronomic, economic and nutritional characteristics.

4.2.2. NUS selection and characteristics

The NUS selection methods followed several steps and was undertaken by stakeholders of GIZ and FSA/UAC. Firstly, a census of all existing edible plant species in the study area was made by literature review. The literature review was based on information collected in articles, project reports, the PROTA4U database[1] and the flora of Benin by (DeSouza 2008). This led to secondary data on different characteristics of the species such as their origin, geographical distribution, different forms and fields of use and possible economic valorisation. Secondly, twenty priority species were selected by using a prioritisation method. The six prioritisation criteria included different geographical, economic and ethnobotanical aspects (Table 3). Thirdly, four prioritisation methods were applied to 20 priority species. They included the point counting procedure, the point counting procedure with weighting, the compound ranking system and the binomial ranking system. Each of the methods resulted into a list of priority species. The number of times each species appeared in the different lists was noted and allowed to identify the eleven species with the highest priority to be selected.

Table 3 Prioritisation criteria for selection of NUS

Criteria	**Categories**
Origin of the species	Autochthonous; allochthonous; introduced; no data
Economic value	International; national; regional; local level; no data
Ethnobotanical value or use	Food; medicinal; cultural; artisanal; socio-economic; other
National distribution	Number of phytodistricts hosting the species
Valued organ	Root; fruit; root; leaf; seed; endocarp; sap; flower
Level of valuation	International; national; regional; local; no data

The selected NUS include three annual and eight perennial plant species of eight plant families (Table 3). With the exception of four introduced species, the remaining ones are native to Benin (RBG). According to former studies, six of the species are classified in the continuum from wild to cultivated, three are cultivated and two are wild growing. Besides *C. gynandra*, *O. gratissimum* and *V. radiata*, the remaining species have several consumed plant parts. Most fruits are harvested during the dry season and most leaves during the rainy season (Avohou et al. 2012; Bvenura and Sivakumar 2017; Chadare et al. 2008; Dansi et al. 2008; Shackleton et al. 2009;

[1] https://www.prota4u.org/database/

Schippers 2000; Kouyaté and Lamien 2011; Dinssa et al. 2016; Achigan–Dako et al. 2010; Assogbadjo et al. 2012; Lamien et al. 2011; Ojelel et al. 2019; Keatinge et al. 2011).

Table 4 Characteristics of the selected NUS

Plant species	Family	Vernacular name	Life form	Origin	Domestication grade	Consumed part	Harvest period	References
 Source: own photo ***Adansonia digitata* L.**	Bombacaceae	African baobab	Tree	Native to Benin	Wild-cultivated	Leaves, pulps, seeds	Dry season (fruits), rainy season (leaves)	Avohou et al. 2012; Bvenura and Sivakumar 2017; Chadare et al. 2008; RBG
 Source: own photo ***Balanites aegpytiaca* (L.) Delile**	Zygophillaceae	Desert date	Tree	Native to Benin	Wild	Leaves, pulps, seeds	Dry season (fruits)	Bvenura and Sivakumar 2017; RBG
 Source: own photo ***Blighia sapida* K.D. Koenig**	Sapindaceae	Akee	Tree	Native to Benin	Wild-cultivated	Leaves, pulps	All season (leaves), rainy season (fruits)	Dansi et al. 2008; RBG; Shackleton et al. 2009
 Source: RBG ***Cleome gynandra* L.**	Cleomeceae	Spider plant	Herbaceous plant	Native to Benin	Wild-cultivated	Leaves	Rainy season (leaves)	Bvenura and Sivakumar 2017; Dansi et al. 2008; Schippers 2000; RBG
 Source: Dressler et al. 2014 ***Detarium microcarpum* Guill. & Perr.**	Leguminosae	Sweet detar	Tree	Native to Benin	Wild, but managed	Pulps, seeds	Dry season (fruits)	Kouyaté and Lamien 2011, RBG
 Source: own photo ***Hibiscus sabdariffa* L.**	Malvaceae	Roselle	Shrub	Introduced to Benin	Wild-cultivated	Calyces, leaves, seeds	Rainy season (leaves)	Bvenura and Sivakumar 2017; Dansi et al. 2008; Dinssa et al. 2016; RBG; Schippers 2000
 Source: own photo ***Moringa oleifera* Lam.**	Moringaceae	Drumstick tree	Tree	Introduced to Benin	Cultivated	Bark, leaves, flowers, pods, roots, seeds	Rainy season - all season	Dansi et al. 2008; Ebert 2014; RBG; Schippers 2000; Shackleton et al. 2009
 Source: RBG ***Ocimum gratissimum* L.**	Lamiaceae	Fever plant	Herbaceous plant	Introduced to Benin	Cultivated	Leaves	Rainy season - all season (leaves)	Dansi et al. 2008; RBG

 Source: Dressler et al. 2014	***Parkia biglobosa* (Jacq.) R.Br. ex G.Don**	Leguminosae	African locust bean tree	Tree	Native to Benin	Wild-cultivated	Leaves, flowers, pulps, seeds	Dry season (pulps, seeds)	Achigan-Dako et al. 2010; Assogbadjo et al. 2012; Lamien et al. 2011; RBG
 Source: own photo	***Tamarindus indica* L.**	Leguminosae	Tamarind	Tree	Native to Benin	Wild-cultivated	Flowers, leaves, pods, pulps	Dry season (fruits)	Ojelel et al. 2019; Schippers 2000; RBG
 Source: own photo	***Vigna radiata* (L.) R.Wilczek**	Leguminosae	Mungbean	Herbaceous plant	Introduced to Benin	Cultivated	Seeds	All season	Keatinge et al. 2011; RBG

4.3. Research region

The study was conducted in the three selected communes of the department of Atacora which belongs to the twelve departments in Benin (Figure 3). Benin's neighbouring countries are Togo, Burkina Faso, Niger and Nigeria.

Figure 3 Map of Benin with its twelve departements (source: INSAE and ICF 2019)

4.3.1. Study area

Benin is spanned by three biogeographical zones (Guineo-Congolese zone, Sudano-Guinean zone, Sudanian zone), whereby the northern part of the country belongs to the Sudanian zone. The dry tropical climate in the Sudanian zone of Benin is characterised by a rainy season usually ranging from May to September and a dry season from October to April. Mean annual rainfall is 900-1100 mm and temperatures are ranging from 24-31°C (Achigan-Dako et al. 2011). The soils are of tropical ferruginous type with deep waterlogging and the main

vegetation types in the countries' northern part are tree and shrub savannas. Benin's ecosystems count more than 2'800 plant species, with a varying species' diversity across the country's biogeographical zones (Akoègninou et al. 2006). The most diversified among the 185 families in terms of species number are Leguminosae (14.8%), Poaceae (9.3%) and Rubiaceae and Cyperaceae (5% each) (Adomou 2005). Most frequently mentioned wild edible trees in Sudanian agroforestry ecosystems include tree species such as *V. paradoxa, P. biglobosa, T. indica, B. aethiopum, D. mesipiliformis, A. digitata* and *V. doniana* (Assogbadjo et al. 2012). From 245 used traditional vegetables reported in Benin, the majority (72%) are classified as wild, although the most widely consumed vegetables are cultivated ones (Achigan-Dako et al. 2011).

Benin has approximately 11.49 million residents (state 2018) (World development indicators database 2019) and is classified as a high commodity-dependent (high import and high export) low-income country (FAO et al. 2019). Approximately 42 sociolinguistic groups are living in Benin. The main sociolinguistic groups in the Atacora department are Batombou, Dendi, Fon, Natimba, Otamari, Fulani, Waama and Yoruba (Achigan–Dako et al. 2010). 40.1% of Benin's population are estimated to live below the national poverty lines (state 2015). Overall life expectancy at birth is 61 years. The average fertility rate is 4.9 and 81% of children complete the primary school (state 2018) (World development indicators database 2019). Prevalence of undernourishment in the total population is estimated at 10.1% corresponding to 1.2 million people (state 2016-18) (FAO et al. 2019). Diets in rural households in Benin are low in diversity and in quality, predominately composed of starchy staples with a small proportion of animal products and fresh fruits and vegetables (Sodjinou et al. 2009).

4.3.2. Selection of study communes and villages

The department of Atacora is bordered by Togo in the West and Burkina Faso in the North. Furthermore, it is adjacent to the departments of Alibori, Borgou and Donga. The majority of the approximately 770'000 residents belong to the rural population. The main economic activities in the Atacora department are agriculture, craft, and trade. The principal cultures in agricultural production include maize, yams, soja, sorghum, black-eyed peas, millet, manioc and groundnut (Fogny and Trentmann 2016). Important cash crops are cashew nut, groundnut, pineapple and cotton (Achigan–Dako et al. 2010).

The three selected communes Natitingou, Toucountouna and Tanguiéta belong to the five of nine communes of the Atacora department in which the activities of ProSAR of GIZ take place (Natitingou, Toucoutouna, Tanguiéta, Pehunco and Kerou). Due to financial constraints and logistical reasons, the projects' research activities took place within the three adjacent communes of Natitingou Toucoutouna and Tanguiéta. In each commune, two villages were randomly selected, in which the semi-structured interviews with local experts and focus groups took place (Table 5). Semi-structured interviews with professional experts were also conducted within the three communes.

Table 5 Characteristics of the selected communes (INSAE 2016)

Commune	**Surface (km^2)**	**Number of residents**	**Number of villages**	**Selected villages**
Natitingou	3045	103'800	65	Kampouya Koukouabirgou
Toucountouna	1600	39'800	22	Tectibayayaou Wabou
Tanguiéta	5456	74'700	38	Douani Kosso

4.4. Sampling

Suitable for in-depth studies of a certain phenomenon are non-probability samplings. In this study, a purposive sampling was used to select informative interview partners in the area of interest (Bernard 2017). Most appropriate key informants for addressing issues related to traditional food systems in a commune include elderly people who consistently reside in the commune and are familiar with the changes that have taken place during the last several decades, nutritional gatekeepers or primary caretakers in households, local health professional experts, agricultural extension workers, or vendors, who are knowledgeable about the topics under review (Fanzo et al. 2011).

Thus, two groups of key-informants were identified based on the required information on the food environment and its influences on consumption of the selected eleven NUS. The first group consisted of local experts living in one of the selected villages of the research area for a considerable period. The local knowledge of these people is assumed to be accumulated through experiences and observations over generations (Davis and Wagner 2003). The second group of key-informants were professional experts, working in the field of agriculture, nutrition, and health. They are assumed to have clear ideas about why people do what they do in the research area and can help to interpret the information with regard to its cultural significance (Albuquerque et al. 2014). A third group of interview partners were focus groups participants, whose discussions allowed to get different opinions, feelings and perceptions (Krueger and Casey 2014). They included nutritional gatekeepers and primary caretakers, but also other members of the local communities of the six selected research villages. An overview of the interview partners in semi-structured interviews and focus group discussion is presented (Table 6 with detailed information Annex 13.3).

Table 6 Sociodemographic characteristics of sampled interview partners

Interview partner	Local experts		Professional experts		Focus group participants	
Variable	**Total (n=24)**	**Statistics**	**Total (n=18)**	**Statistics**	**Total (n=72)**	**Statistics**
Sex						
Female	7	29%	6	33%	36	50%
Male	17	71%	12	67%	36	50%
Age (years)						
Mean	59		34		41	
Range	50-71		24-52		18-80	
Residential community						
Natitingou	8	33%	9	50%	24	33%
Tanguiéta	8	33%	7	39%	24	33%
Toucoutouna	8	33%	2	17%	24	33%
Duration of residence (years)						
Mean	57		No data available	No data available	35	
Range	25-71		No data available	No data available	6-72	
Ethnic affiliation						
Waama	15	67%	3	17%	48	67%
Otamari	2	17%	2	11%	12	17%
Natimba	7	17%	-	-	9	13%
Berba	-	-	3	17%	2	3%
Fulani	-	-	-	-	1	1%
Dendi	-	-	2	11%	-	-
Fon	-	-	2	11%	-	-
Other	-	-	6	33%	-	-
Highest education level						
None	13	54%	-	-	30	42%
Until 3nd grade	15	21%	-	-	15	21%
Until 6 th grade	8	33%	-	-	14	19%
Until 9th grade	3	13%	2	11%	5	7%
Until 12th grade	-	-	4	22%	4	6%
Bachelors	-	-	7	39%	-	-
Masters	-	-	5	28%	-	-
Occupation						
Farmer	24	100%	-	-	72	100%
Agricultural advisor	-	-	4	22%	-	-
Nutritional advisor	-	-	11	17%	-	-
Others	-	-	3	17%	-	-
Religious background						
Christianity	16	63%	No data available	No data available	30	42%
Traditional religions	4	29%	No data available	No data available	36	50%
Muslims	-	-	No data available	No data available	6	8%
None	4	8%	No data available	No data available	-	-

4.4.1. Local and professional experts

Local experts were chosen based on the criteria of being at least 50 years old and with a longstanding history of living in one of the six selected research villages of Natitingou, Toucountouna and Tanguiéta. In total, 24 local experts were selected and interviewed (4 per village/8 per commune). All 7 female and 17 male local experts were (former) farmers. Mean age of the respondents was 59 years. Overall mean duration of residence in the research village was 57 years. The respondents belonged to the ethnic groups Waama (15 respondents), Natimba (7 respondents) and Otamari (2 respondents). Approximately half of the respondents had no formal education, whereas the remaining respondents had been in primary school.

Professional experts were selected based on their professional experience in the field of agriculture, nutrition, and health with direct contact with the local population living within the three selected communes. A preferably balanced mix of their professional intervention zones within the research area as well as gender distribution was envisaged. In total, six female and 12

male respondents between 24-52 years were interviewed (mean age 34 years). Half of the 18 respondents resided in the commune in Natitingou. Eleven respondents were active as nutritional advisors, four as agricultural advisors and the remaining three respondents worked as a farm director, social worker and scientist. Professional experts belonged to eleven ethnic groups. Two-third of the professional experts held at least a bachelor's degree.

4.4.2. Focus group participants

Selection of participants for focus group discussions envisaged to depict different profiles of the rural population in the research area. Therefore, participants from various age groups, religious, educational, and sociolinguistic backgrounds were selected. Participants of semi-structured interviews with local experts and village chiefs were excluded and preferably, no participants from the same household were selected. Discussions with men and women were conducted separately to enhance free exchange of opinions. A maximal number of six participants in cross-lingual and -cultural focus groups is recommended (Quintanilha et al. 2015). In total, 72 respondents participated in the 12 focus groups with six participants per group. The respondents mean age was 41 years, ranging from 18-80 years. Mean residential duration in the research villages was 35 years, ranging between 6-72 years. All respondents were farmers. In Natitingou, two focus groups took place with people from the sociolinguistic group of Waama, another two in Ditamari. In Toucountouna, focus group participants belonged to the sociolinguistic group of Waama. In Tanguiéta, two focus group participants consisted of Waama, another two were with mixed ethnic groups (Fulani, Natimba, and Berba respectively Natimba and Berba). Religious affiliation varied among participants of most focus groups discussions. Only in three focus groups, participants were uniquely followers of traditional religions. The education level varied from participants without formal education to the secondary degree.

4.5. Data collection

Data collection was conducted from 21.10.-23.11.2019 for a period of 34 days (including training sessions with the enumerators and conduction of pre-tests). In a first step, semi-structured interviews with local and professional experts were carried out. Focus group discussions took place in a second step with parallel conduction of further interviews with professional experts. Due to language barriers between myself and most research participants, interviews with local experts and focus group participants were conducted with the help of two enumerators in local languages. Professional experts were interviewed by me in French.

All interviews were oriented to the conceptual framework based on the four dimensions of the personal food environment and their aspects (chapter 3 Table 1). During data collection, the same visual stimuli were used in form of photographs of the selected NUS. For each NUS, a collage of four pictures illustrating the NUS and their edible plant parts was prepared (Annex 13.1). The photographs' main function was to make the selected NUS easily identifiable for the interview partners. The photographs were numbered from 1-11 for easier handling of the eleven species (especially for the ranking tasks). Before each interview or group discussion, the projects' background and the interview procedure were explained. The information sheet and consent form (Annex 13.2), which included information about the background and aims of the study, handling of data, rights of the interviewees, had to be signed by each participant before the start of the interviews. This also included the permission to record the interviews, to take notes and photographs.

In the following, the different sub-steps in data collection, including the enumerators' selection and training, the pre-tests and collection of data are described.

4.5.1. Enumerators selection, training procedure and role

Two enumerators were selected for the whole data collection period. Their selection and training procedure followed the methodological recommendations for cross-language qualitative research (Squires 2009). Criteria for selection included the enumerators' availability for the complete data collection period, their formal and language qualifications (for the languages Waama, Ditamari and Naténi which were mainly spoken in the research villages) as well as their previous experience in GIZ projects. The two chosen enumerators were male persons at the age of 28 and 36 years. They grew up and were living in the commune of Natitingou and held a bachelor and master's degree in agronomy. Their mother languages were Waama/Ditamari and Waama.

The enumerators training was split into a first training session for the semi-structured interviews with local experts at the start of the research period and a second training for the focus group discussions at half of the research period. Most of the time of the training sessions was dedicated to the conduct as well as content-related and methodological aspects of the interviews. Parallel to the data collection, each of the enumerators translated and transcribed half of the semi-structured interviews with local experts and half of the focus group discussions from local languages to French. The translation of the recorded interviews followed the principle of "conceptual equivalence". Thus, the enumerators translated not the literal meaning of the words but adjusted them to the concepts meant by the research participants (Squires 2009). The transcripts were continuously read and discussed among the research team and if needed, additional context information was noted. The translation consisted of an additional interpretative step which took place before the actual data analysis started (Bogner et al. 2014). Sociocultural meanings, beliefs, values are mediated through language and communication and translators and interpreters have an active role in the knowledge-creation process (Liamputtong 2008).

4.5.2. Semi-structured interviews

In total, 24 semi-structured interviews with local experts and 18 interviews with professional experts were conducted, after some pre-tests had been carried out.

4.5.2.1. Pre-tests

Five pre-tests were carried out with local experts in two villages of Natitingou known by the enumerators. The interview partners were chosen based on their short-notice availability and regarding the selection criteria. During the interviews, enumerators and I communicated with each other to clarify questions and to catch up with the interview content. The interviews were recorded and afterwards partly transcribed by the enumerators. Full transcription of the pre-tests was not possible due to time constraints, but de-briefings took place. The interview guidelines were continuously adapted regarding repeating questions in the end part and towards simplified versions of some questions. Procedure and timeline of the interviews, experienced difficulties and further suggestions for improved data collection process were discussed.

Parallel to this, I conducted two pre-tests with professional experts from two NGO's based in Natitingou. These pre-tests took place in the public space and at the GIZ office in Natitingou. The conversations were recorded and afterwards partly transcribed. After the first pre-test, repeating questions in the guideline were deleted. The guidelines' structure was changed to a more convenient version which gave a better overview of the main part. This adapted guideline was used in the second pre-test, after which only some wording was improved.

4.5.2.2. Interviews

Usually four interviews with local experts took place per day within the public space of their home villages. I was present in two of the six research villages and my interventions during the

interviews gradually diminished with the ongoing data collection. After each day of data collection, a debriefing between the enumerators and myself took place.

Parallel, contacts of potential professional experts were provided by staff members of the local GIZ team of ProSAR. I additionally called and visited stakeholders of additional organisations located in Natitingou to get the fullest possible picture of professional experts being active in one of the related fields in the research area. This resulted in a list of approximately 40 potential key-informants, including members of advisory services, social promotion center workers and local nutritionists working in the private or public sector. Of each contact organisation, at least one person was contacted and if possible, an interview appointment was fixed.

The interview guidelines with local and professional experts followed the same structure. The interview guidelines (Annex 13.4.1/13.4.2) only differed slightly in contents and wording but applied different perspectives on the personal food environment. Whereas local experts were questioned about their personally perceived changes in the consumption of the selected NUS and related shifts in their personal food environment, professional experts were asked about the changes they perceived while working with local community members' within the research area. After an introductory part covering rankings among all known NUS by the interview partners, a random selection of NUS (Annex 13.5) was discussed in-depth per interview.

4.5.3. Focus group discussions

In total, two pre-tests and 12 focus groups in the six selected villages took place. In each of the six research villages, two focus groups were separately conducted with a group of six women and men.

4.5.3.1. Pre-tests

The first out of two pre-tests were conducted with a group of six men in a randomly chosen village in Natitingou on 6.11.2019. The main part of the focus group discussion consisted of a matrix ranking. Such scoring techniques are used to quantify people's level of importance of specific factors (Bernard 2017). In this case, the influencing dimensions and aspects on consumption of each NUS were rated based on an ordinal scale with fixed numbers of ratings for each factor. The species' photographs were put in the x-axis and the factors on the y-axis. A large paper was prepared, which could be put on the floor and two columns for negative or positive influences of factors were drawn (Photo 1). Factors were symbolised with pictures and their meanings explained to the participants, who were asked to rate the type of influence (positive/negative) and importance of each factor based on a four-scale scale (0=no importance, 1=low importance or influence, 2=medium importance, 3=high importance). After the rating task, a short discussion was held on the given, visualised results of the matrix.

Photo 1 Pre-test with participatory rating

This procedure was planned to be repeated for each of the eleven NUS. However, after almost two hours, the rating task was only completed for two of the eleven species. Several difficulties were experienced during this pre-test. Firstly, the participatory rating was not adapted to the high number of NUS, their different plant parts and influences which must be discussed. Secondly, it took a lot of effort to explain the procedure of the rating and possible positive and negative influences and their degree. Consequentially, participants were mainly discussing the degrees of influence (0-3) and less the influences' characteristics and underlying aspects. Thirdly, participants often decided commonly how to rate a factor. A tendency of dominancy of some participants could be observed without much controversy on the type and degree of each influence. Further practical reasons complicated the participatory rating. The rating demanded permanent involvement of each participant as well as constant getting up to complete the ratings, which was for instance complicated for mothers who had their children with them.

Thus, in the second pre-test, the rating task was eliminated and replaced by questions about the food environments' dimensions and aspects related to the eleven NUS. Examples of positive and negative influences from the semi-structured interviews were integrated into the interview guideline (Annex 13.4.3) to deepen their understanding. This second pre-test with a group of women in another village in Natitingou showed that it was feasible to discuss half of the eleven NUS within one focus group and enabled more balanced participation of all participants involved as well as deeper levels of information.

4.5.3.2. Interviews

The focus group discussions took place within the public spaces of the research villages, usually in the shadow of a tree. I assisted 10 of 12 focus group discussions. My absence in the village of Douani (commune of Tanguiéta) was due to security reasons. For the focus group discussions, the eleven species were divided into two groups. Per village, half of the species were discussed with the female, the other half with the male group (Table 7). Since in the other village of the same commune the distribution of the species by women and men was reversed, each species was discussed once with a male and once with a female group of the same commune.

Table 7 Overview of focus group discussions

Focus groups (n=12)	Commune	Village	Number of participants	Sex of participants	Spoken language	Selected species*
1	Natitingou	Kampouya	6	Men	Waama	1-6
2			6	Women	Waama	7-11
3		Koukouabirgou	6	Men	Ditamari	7-11
4			6	Women	Ditamari	1-6
5	Toucountouna	Tectibayayaou	6	Men	Waama	7-11
6			6	Women	Waama	1-6
7		Wabou	6	Men	Waama	1-6
8			6	Women	Waama	7-11
9	Tanguiéta	Kosso	6	Men	Waama	7-11
10			6	Women	Waama	1-6
11		Douani	6	Men	Natenie	1-6
12			6	Women	Natenie	7-11

*1-6: *B. sapida, D. microcarpum, H. sabdariffa, M. oleifera, O. gratissimum, T. indica* ,
7-11: *A. digitata, B. aegyptiaca, C. gynandra, P. biglobosa, V. radiata*

4.6. Data retention

A total of 24 semi-structured interviews with local experts and 12 focus group discussions were audio recorded in local languages by the two enumerators. They translated and transcribed the records to French and the files were saved as word documents. The 18 semi-structured interviews with professional experts were directly audio recorded in French and transcribed by me and saved as word documents. Furthermore, data collection was accompanied by photographs and a personal field diary.

4.7. Data analysis

Data of the transcribed text material from the 42 semi-structured interviews and the 12 focus group discussions were analysed from a content-perspective. In addition, the rankings were separately analysed by descriptive statistics.

4.7.1. Rankings

Quantitative data from the rankings that originate from the ordering of photographs of the eleven NUS were analysed by descriptive statistics (frequencies). For each ranking criterion, the NUS with the perceived highest value was given the value 1, the NUS with the perceived lowest value was given the number 11. Species which were ranked with the same value were treated as follows: the number of species with the same rank was omitted and it was continued with the value, which comes after this number. The scores cited by each of the respondents were added for each plant which results in a total score for each NUS. In a second step, this total is divided by the number of interview partners which resulted in a mean for each NUS. The lower the mean value, the higher was the rank of the species for the specific criterion (Albuquerque et al. 2014). For semi-structured interviews, overall mean rankings of the eleven species were then calculated through the ranked sums of the different interview groups (local and professional experts). For focus groups, the eleven species were ranked in two groups due to their division in the focus group discussions.

4.7.2. Qualitative content analysis

Qualitative content analysis provided a systematic way of analysing the collected interview data (Bogner et al. 2014). Relevant content was delimited by the research questions and the elaborated conceptual framework. The first step of the qualitative content analysis involved coding, where relevant information from the 54 text documents was extracted according to the developed category system. The second step of content structuring consisted of paraphrasing, generalising, and reducing the coded text passages and finally led to derived answers to the research questions.

4.7.2.1. Coding

The unit of analysis were the text passages of the interviews (42 semi-structured interviews and 12 focus group discussions). The applied category system consisted of 14 categories and their definitions which derived deductively from the conceptual framework in reciprocal consideration of theories, research questions and the collected data material (Table 8). For each NUS, 14 categories were assigned to a category group named after each species. Category numbers 1-9 comprised the influencing dimensions and aspects of the personal food environment, while the categories 10-13 captured positive, negative, neutral changes in consumption as well as changes in the consumption mode over time and at present. Category number 14 called “consumption” described the contemporary consumption of each of the eleven NUS.

Table 8 Category system

Number	Category	Description
1	Accessibility	Physical distance, time- and transport-based aspects relative to individuals which influence consumption of the species X
2	Affordability	Purchasing power which influences consumption of the species X
3	Convenience	Time and effort needed which influence consumption of the species X
4	Informal institutions	Norms of behaviours, conventions and self-impose codes of conducts which influence consumption of the species X
5	Social markers	Social status and group membership which influence consumption of the species X
6	Ecological and biological knowledge and skills	Knowledge on phenology, propagation modes and seed storage methods and about the relationship between humans, animals, plants, and the physical elements of their environment as well as related management which influence consumption of the species X
7	Food and nutrition knowledge and skills	Attributes related to facts and information acquired through experience or education related to foods and nutrition as well as techniques of food purchasing, preparation, handling and storage which influence consumption of the species X
8	Preferences for sensory properties	Sensory responses to taste, smell, consistency, texture and visual appeal which influence consumption of the species X
9	Additional factors	Factors which cannot be categorised into one of the categories and which influence consumption of the species X
10	Increase of consumption level	Positive change of consumption level of the species X

11	Decrease of consumption level	Negative change of consumption level of the species X
12	Neutral change of consumption level	No change of consumption level of the species X
13	Change of consumption mode	Change in the way of consumption of the species X
14	Consumption	Current characteristics of consumption of the species X

All text material was coded after the same procedure using the software ATLAS.ti. In a first step, the material was systematically filtered for information based on the category system. This process of selecting relevant information was based on the researcher's interpretation (Bogner et al. 2014). The unit of analysis was defined as the smallest as possible, but still comprehensible text passage. During the coding process, no new categories were added to the framework. However, existing categories were further specified and delimited from others. Some assignments which were coded inconsistently, became more sharply separated from other categories. Some single coded text passages were also summarised in a second coding procedure to capture interactions between factors. The assigned text passages to the code "additional factors" were summarised under the term "physiological needs".

4.7.2.2. Content structuring

The aim of content structuring was to systematically extract and summarise specific aspects from the coded material, which were primarily determined by the deductively derived category system (Mayring 2007). Thus, the changes in consumption and the related drivers as well as contemporary barriers and enhancing factors of consumption were displayed in a more comprised form. In a first step, the coded text material was translated and paraphrased from French to English as well as generalised according to a defined abstraction level. For this purpose, the text passages coded under the fourteen categories were extracted from the software ATLAS.ti into separate excel files. With ongoing analysis, statements were no longer paraphrased but directly generalised. The abstraction level of generalisation was defined as all characteristics with direct or indirect statements about their influence on consumption regarding to specific plant parts and/or about development of the plant consumption over time. If statements were either wrongly coded or incomprehensible, they were added to the right category or sorted out (marked by "n.a.").

After paraphrasing and generalising all statements, reduction encompasses the review of all generalised statements and were divided into two sub-steps (Mayring 2007). In a first reduction, statements with redundant information were reduced whereas the whole variation in information was kept. This led to the creation of matrices for each category and species. The matrices were guided by the research questions and included the mentioned plant parts of the species in the x-axis and influences over time/current influences and their effects on consumption of the respecting plant part (categories 1-9) in the y-axis. In a second reduction, statements for each NUS were extracted to a word file and further bundled, integrated, and constructed. Statements with similar information about one plant species' factor or its effect on consumption were further summarised (bundling). Statements with different statements were also combined without losing the variation in information (integration and construction).

More in detail, the information from categories 10-14 was used to answer the first and from categories 1-9 to answer the second research questions. Plant parts which were only

occasionally mentioned to be consumed were not considered[2] (*B. aegyptiaca'*s leaves*, B. sapida'*s leaves, *M. oleifera*'s flowers, roots and seeds, *P. biglobosa*'s leaves, *T. indica's* leaves). Their inclusion would have exceeded the scope of data collection and analysis. Regarding the first research question, the frequency of each statement made (increase/decrease/no change of consumption) were counted for each investigated plant part and separately for semi-structured interviews and focus group discussions. Statements from focus group discussions were counted per group because no statements were assignable to individuals (unlike in semi-structured interviews where they were counted per person). Repeating statements by the same interview partner/focus group were not counted. The overall net change for consumption of each investigated plant part resulted from the difference of the total number of increased minus decreased statements divided by the total number of statements. These numbers varying from +1 to -1 were classified into three main trends: increasing trend in consumption (1 to 0.33), varying trend in consumption (0.33 to – 0.33) and negative trend in consumption (-0.33 to -1). Regarding research question 2a, statements for each species were classified after the characteristics of the factor (increased/decreased/unchanged) and its effects on consumption (positive/negative/no influence) and summarised over the three main trends in consumption. Thus, similar changes in drivers and their contributing and counteracting influences on their main trend became visible. For research question 2b, subcategories of each code were inductively developed based on mutual consideration of the theoretical background and the analysed material. Such an inductively based identification of subthemes offers the potential to better include local views (Ryan and Bernard 2003) and to further adapt the conceptual framework to the emerging barriers and promotors. The created overview tables consisted of the investigated plant parts and changes respectively influences of the factors on consumption. Blank spaces indicated that no such factor combinations were mentioned.

In the last step, which called for evaluation of the data, the single sections were converted to continuous text to answer the research questions (Bogner et al. 2014). With the aim of facilitating the text flow, plants were listed in alphabetical order and individual plant parts were only explicitly mentioned in brackets if several plant parts of the same species had been examined. This was the case for three species (*A. digitata*, *H. sabdariffa*, *P. biglobosa*). For the remaining eight plant species, their single investigated plant part was not explicitly mentioned (*B. aegyptiaca, B. sapida, C. gynandra, D. microcarpum, M. oleifera, O. gratissimum, T. indica, V. radiata).*

4.8. Material and equipment

The material and equipment used for data collection included three recording devices, three versions of the printed photographs of the selected NUS, the printed interview guidelines, consent and information forms in double versions for each interview partner (in total 252 versions), note-taking material and leaflets. Furthermore, data collection was photographically accompanied. For the planned rating tasks in focus group discussions, a poster with visualised pictures of each factors and little stones for the ratings in two colours were prepared.

4.9. Approval and authorisation

Before starting the research projects' activities, the research protocol of the planned project was submitted to and approved by the Comité National d'Ethique pour la Recherche en Santé

[2] The following plant parts were mentioned to be consumed: *B. aegyptiaca's* leaves in herbal teas (mentioned *1x), B. sapida*'s leaves in herbal teas (mentioned 1x) or sauce (mentioned 2x), *M. oleifera*'s flowers in sauces (mentioned 3x), roots (mentioned 5x), seeds in herbal tea, local alcoholic drinks or raw (mentioned 7x), *P. biglobosa*'s leaves in herbal teas (mentioned 1x), *T. indica*'s leaves in herbal teas (mentioned 4x) or in sauces (mentioned 6x)

(CNERS[3]). Furthermore, data collection activities were agreed with the political and local authorities and the responsible stakeholders of the nutrition and health sector in the research area. An information sheet about the research project was distributed to the different governmental and non-governmental stakeholders. The aims of the project were also presented to local authorities and their permission was obtained to conduct data collection in their regions.

For this thesis' data collection, an information and consent sheet were handed out to each participant. The consent form included information about the study's objectives and background as well as participants and interviewer's rights and duties. Participants could stop and leave the interview procedure at any time. Data remained confidential and participants were not identifiable in the study's results. The participation in the study was free and voluntary. Transport expenditures were reimbursed. Focus group discussions were followed by a common meal, organised by the research team and prepared by village's residents. Also, permission for sound recording, note-taking, and taking photographs was obtained. If the participants agreed to take part in the study, the consent form was signed or marked by a stamp by both participant and the interviewer. A copy of the consent form was given to each participant and the second version was conserved in the office of Bioversity International in Cotonou, Benin.

4.10. Consideration of ethical questions

The methodological approach followed the principles of ''ethical validity'' which aimed to respect the ethical principles of all research partners (Edwards et al. 2008). The research team focused on learning from and with local people. Informed consent was used, and intellectual and real property rights were acknowledged. During the interviews, questions were asked politely and the willingness not to answer questions was respected. The value of the various resources such as time and knowledge given by the interview partners were appreciated. The further planned project activities, such as the provision of nutritional, ethnobotanical, economic and sociocultural information about the consumption of the selected NUS, awareness-raising activities with local community members, recipe leaflets etc. will hopefully compensate for their efforts.

4.11. Return of findings

The outputs of the project will be presented in each research village. These sessions are organised by Bioversity International, the faculty agricultural sciences at the UAC and their local partners in Benin. A copy of the results of the study is submitted to the ministry of health and of agriculture, livestock and fishery, the national committee of ethics for health research, the national council of food and nutrition, different local authorities in the department of Atacora and different structures involved in the execution of the project. The presented results consist of ideas, suggestions and invitations, which can be implemented on a voluntary basis (McClatchey and Gollin 2005).

Furthermore, a book with recipes will be developed and distributed to local women's associations, commune leaders, NGO's, health centres and other local structures in the field of nutrition and health. At the end of the research activities, Bioversity International and its local and external partners will work on formulating recommendations for efficient interventions with regard to support an enhanced utilisation of the local biodiversity for nutrition and with special attention to vulnerable groups and for the well-being for the whole population.

3 http://ethique-sante.org/

5. Results

5.1. Contextualising the consumption of the selected NUS

The investigated plant parts were consumed in various ways (Table 9). Leaves were mostly consumed as ingredients of sauces; fruit pulps were mostly eaten raw or processed to juices and seeds and kernels were mostly used as condiment in sauces. Besides food consumption, other mentioned uses of the species were for instance externally applied medicinal uses or uses as firewood. The research sample depended primarily on the natural environment (through cultivation and wild harvest) to acquire the investigated plant parts, complemented by market-based (with exception of *C. gynandra*) and non-monetary transfers. The consumed plant parts of three species were not cultivated but solely harvested from the wild (*B. aegyptiaca*, *D. microcarpum*, *T. indica*), whereas two other species' plant parts were not collected in the wild (*H. sabdariffa*, *V. radiata*). Plant parts of all other NUS were acquired through both the cultivated and wild environment.

All NUS had seasonal production cycles. Plant parts of four species were produced during the rainy season (*C. gynandra*, *H. sabdariffa*'s leaves, *M. oleifera*, *V. radiata*), whereas the remaining plant parts of seven species were mainly produced during the dry season (*A. digitata*'s leaves and *pulps, B. aegyptiaca*, *B. sapida*, *D. microcarpum*, *H. sabdariffa*'s calyces and seeds, *P. biglobosa*, *T. indica*). The plant parts' consumption period could be extended beyond their maturing period through processing and storage activities of harvested products and/or other sources of acquisition such as purchase or non-monetary transfers.

Table 9: Characteristics of consumption of the eleven NUS' plant parts

Plant species	Consumed part	Mode of consumption	Source of acquisition	Level of consumption	Period of consumption	Non-food use
***Adansonia digitata* L.**	Kernels	Condiment; crushed, dried, grilled or as fermented paste in sauces	Harvest from own cultivation; wild harvest; purchase; transfer	Low	Dry season - whole year	
	Leaves	Fresh or dried in sauces or porridges	Harvest from own cultivation; wild harvest; purchase; transfer	High	Dry season - whole year	Potash production (roots)
	Pulps	Raw; crushed in porridges and other dishes; juices	Harvest from own cultivation; wild harvest; purchase; transfer	Low - high	Dry season - whole year	
***Balanites aegpytiaca* (L.) Delile**	Pulps	Raw; prepared	Wild harvest; purchase; transfer	Lack of consumption - low	Dry season	Firewood; external treatment of cutaneous infections (leaves); malaria (roots)
***Blighia sapida* K.D. Koenig**	Arils	Raw; prepared fresh or dried in sauces	Harvest from own cultivation; wild harvest; purchase; transfer	Low - high	Dry season	Firewood; potash prodcution (skin of aril and seeds); external treatment of dentition; malaria (leaves)
***Cleome gynandra* L.**	Leaves	Fresh as salad, prepared as vegetable, patties or in sauces	Harvest from own cultivation; wild harvest; transfer	Low - high	Rainy season	Potash production (leaves); external treatment of headache; malaria (leaves)
***Detarium microcarpum* Guill. & Perr.**	Pulps	Raw or grilled; beverage	Wild harvest; purchase; transfer	Lack of consumption - low	Dry season	Firewood; external treatment of malaria; stomach pain; swellings; inflammations; vertigo (roots)

	Calyces	Prepared as vegetable; juice	Harvest from own cultivation; purchase; transfer	Low - high	Dry season - whole year	
***Hibiscus sabdariffa* L.**	Leaves	Prepared in sauces	Harvest from own cultivation; purchase; transfer	Lack of consumption - low	Rainy season - whole year	External treatment pf snake poisson (leaves)
	Seeds	Prepared as fermented paste in sauces	Harvest from own cultivation; purchase; transfer	Lack of consumption - low	Dry season - whole year	
***Moringa oleifera* Lam.**	Leaves	Fresh, dried and crushed to powder in sauces or added to other dishes; herbal tea	Harvest from own cultivation; wild harvest; purchase; transfer	Low - high	Rainy season - whole year	External treatment of muscle soreness, swellings, inflammations (roots)
***Ocimum gratissimum* L.**	Leaves	Condiment, fresh in sauces; herbal tea	Harvest from own cultivation; wild harvest; purchase; transfer	Lack of consumption - high	Whole year	Potash production (leaves)
***Parkia biglobosa* (Jacq.) R. Br. ex G. Don**	Seeds	Fresh or grilled seeds; fermented paste in sauces; beverage	Harvest from own cultivation; wild harvest; purchase; transfer	High	Whole year	Firewood; animal feed (pulps); external treatment of toothache (leaves) toothpick (rods)
	Pulps	Raw, prepared in porridges; juice	Harvest from own cultivation; wild harvest; purchase; transfer	Low - high	Dry season - whole year	
***Tamarindus indica* L.**	Pulps	Prepared in porridges; juice	Harvest from own cultivation; wild harvest; purchase; transfer	Lack of consumption - low	Dry season - rainy season	Firewood; external treatment of malaria (roots); stomach pain; swellings; inflammations (bark)
***Vigna radiata* (L.) R.Wilczek**	Seeds	Prepared as lentil puree, fritters or added to other dishes	Harvest from own cultivation; purchase; transfer	Lack of consumption - high	Dry season - whole year	Treatment of jaundice (leaves)

Plant parts of most NUS had highly varying consumption levels. High consumption levels were reported for two plant parts (*A. digitata's leaves*, *P. biglobosa's seeds*). In contrast, five plant parts were on a low consumption level (*B. aegyptiaca*, *D. microcarpum*, *H. sabdariffa*'s leaves and seeds, *T. indica*). With a minority of respondents, some investigated plant parts lacked recognition (*B. aegyptiaca, C. gynandra*, *T. indica*) and/or lacked consumption (*B. aegyptiaca*, *B. sapida*, *C. gynandra*, *D. microcarpum*, *H. sabdariffa*'s leaves and seeds, *O. gratissimum*, *P. biglobosa*'s *pulps, V. radiata*). Deeper insights in the relative consumption frequencies and preferences among the eleven NUS were indicated through their rankings[4] (Table 10). Most and least frequently consumed species were identical with the most and least preferred ones. *P. biglobosa*, *A. digitata* and *H. sabdariffa* were the most frequently consumed and preferred species, whereas *B. aegyptiaca*, *O. gratissimum* and *D. microcarpum* were on the lowest ranks.

[4] No distinction between different investigated plant parts of each species was made

Table 10: Mean ranking for consumption preferences and frequencies

Consumption preferences				Consumption frequencies			
Mean ranking		Overall mean ranking		Mean ranking		Overall mean ranking	
Local experts (n=24)	Professional experts (n=17)			Local experts (n=24)	Professional experts (n=17)		
1.50	2.65	1st	*P. biglobosa*	1.67	2.59	1st	*P. biglobosa*
4.00	2.35	2nd	*A. digitata*	3.17	2.71	2nd	*A. digitata*
4.92	4.53	3rd	*H. sabdariffa*	4.67	4.06	3rd	*H. sabdariffa*
4.21	5.41	4th	*B. sapida*	6.04	3.06	4th	*M. oleifera*
6.29	3.71	5th	*M. oleifera*	4.17	5.53	5th	*B. sapida*
5.29	5.29	6th	*T. indica*	5.33	5.29	6th	*T. indica*
4.75	6.12	7th	*V. radiata*	5.25	6.00	7th	*V. radiata*
6.42	5.35	8th	*C. gynandra*	6.25	5.35	8th	*C. gynandra*
6.88	5.41	9th	*B. aegpytiaca*	6.96	5.18	9th	*B. aegpytiaca*
6.92	5.71	10th	*O. gratissimum*	7.63	5.00	10th	*O. gratissimum*
10.17	8.65	11th	*D. microcarpum*	9.54	7.76	11th	*D. microcarpum*

Regarding the potential for increased consumption of the eleven NUS (Table 11), focus group participants jointly rated their preferences for enhanced consumption of their discussed group of six respectively five NUS. The most potential for enhanced consumption resulted in mean for *M. oleifera*, evaluated by professional experts and *M. oleifera* and *P. biglobosa*, evaluated by focus groups. Least potential for enhanced consumption was assigned by all respondent groups to *B. aegyptiaca* and *D. microcarpum.*

Table 11: Mean ranking of potential and preferences for enhanced consumption

Potential for enhanced consumption					
Mean ranking Professional experts (n=18)			Mean ranking Focus groups (n=12)		
All species selected			**1st group of selected species**		
2.7	1st	*M. oleifera*	1.33	1st	*M. oleifera*
3.3	2nd	*A. digitata*	2.50	2nd	*H. sabdariffa*
3.5	3rd	*P. biglobosa*	2.67	3rd	*O. gratissimum*
3.8	4th	*V. radiata*	3.67	4th	*B. sapida*
4.1	5th	*B. aegpytiaca*	4.00	5th	*T. indica*
4.7	6th	*H. sabdariffa*	5.83	6th	*D. microcarpum*
4.8	7th	*B. sapida*	**2nd group of selected species**		
5.3	8th	*C. gynandra*	1.00	1st	*P. biglobosa*
5.6	9th	*T. indica*	2.00	2nd	*A. digitata*
5.7	10th	*O. gratissimum*	3.33	3rd	*V. radiata*
6.7	11th	*D. microcarpum*	3.67	4th	*C. gynandra*
			4.17	5th	*B. aegpytiaca*

5.2. Changes in consumption of the selected NUS

Changes in consumption over the last decades varied among the selected NUS as well as among different edible plant parts of the same species (Table 12). A major increase in consumption was shown for five plant parts of four species (*C. gynandra*, *H. sabdariffa*'s calyces and leaves, *M. oleifera*, *V. radiata*). For other five plant parts a downward trend in consumption was perceived (*A. digitata*, *B. aegyptiaca*, *D. microcarpum*, *P. biglobosa*, *T. indica*). For the remaining investigated plant parts of four species, statements about their development varied

in a more balanced way between increased, decreased, and unchanged developments (*A. digitata*'s leaves and kernels, *B. sapida*, *H. sabdariffa*'s seeds, *O. gratissimum*, *P. biglobosa*'s seeds).

The different trend in consumption among the investigated plant parts are discussed in the following subchapters.

Table 12 Changes in consumption of the investigated NUS' plant parts

Species	Changes in consumption / Plant part	Increase	Decrease	No change	Increase	Decrease	No change	Overall net change	Main trend
		Number of statements by local and professional experts (n=42)			Number of statements by focus groups (n=12)			(n=54)	
M. oleifera	Leaves	20	1	1	5	0	0	**0.89**	**Increase**
C. gynandra	Leaves	4	1	1	5	0	0	**0.73**	**Increase**
H. sabdariffa	Calyces	5	1	0	1	0	0	**0.71**	**Increase**
H. sabdariffa	Leaves	4	0	2	1	1	0	**0.50**	**Increase**
V. radiata	Seeds	12	7	0	5	0	0	**0.42**	**Increase**
A. digitata	Leaves	4	3	3	2	0	1	**0.23**	**Varied**
P. biglobosa	Seeds	7	6	2	2	0	3	**0.15**	**Varied**
H. sabdariffa	Seeds	3	2	2	0	0	0	**0.14**	**Varied**
O. gratissimum	Leaves	4	5	2	2	0	0	**0.08**	**Varied**
B. sapida	Arils	2	7	3	4	1	0	**-0.12**	**Varied**
A. digitata	Kernels	1	5	2	2	0	1	**-0.18**	**Varied**
A. digitata	Pulps	3	11	3	1	0	1	**-0.37**	**Decrease**
T. indica	Pulps	3	10	0	1	2	0	**-0.50**	**Decrease**
B. aegpytiaca	Pulps	0	6	0	2	2	1	**-0.55**	**Decrease**
P. biglobosa	Pulps	1	14	1	0	4	3	**-0.74**	**Decrease**
D. microcarpum	Pulps	0	17	1	0	3	1	**-0.91**	**Decrease**

5.2.1. Increasing trend in consumption

The clearest trend for increased consumption was shown for *M. oleifera*'s leaves whose consumption was at an inexistent to a low level some decades ago. Likewise, the leaves of *C. gynandra,* calyces and leaves of *H. sabdariffa* and seeds of *V. radiata* showed a positive trend. For *H. sabdariffa*, the harvest from own cultivation increased parallel with the sale's level of calyces and leaves. In addition to the consumption of calyces and leaves as an ingredient in sauces, ways of preparation of calyces evolved through their transformation into juices. The positive trend in consumption of *V. radiata*'s seeds was mainly linked to recent times. They were traditionally known and consumed in the research area, although not all respondents stated that they had consumed the species during their youth. Approximately one decade ago, consumption of seeds of *V. radiata* decreased to a practically non-existent level. In recent years, increased harvest from own production and higher consumption levels were observed, although some respondents still mentioned a total lack of consumption of the species' seeds in the present. New ways of preparation included the seeds' integration into traditional meals such as the Beninese dish "atassi/watché" (rice with beans) or in bakery goods such as cakes.

5.2.2. Decreasing trend in consumption

Among the plant parts with the decreasing trend, consumption of *A. digitata*'s pulps decreased, whereas their processing to juices and marketing showed an upward trend. Some decades ago, the pulps were considered as a sweetener and were often directly consumed by children or added to porridges. Also, *T. indica*'s pulps were regularly consumed both as a beverage or added to porridges during the respondent's youth but the contemporary consumption level was comparably low. Whereas the species was considered as a pharmaceutical product of the elder generation, consumption for medicinal purposes decreased. Some decades ago, *P. biglobosa*'s pulps were considered as a staple food and mainly consumed during fieldwork. Also, during periods of hunger, the pulps were dissolved in water and used as a school meal by children. The contemporary consumption level ranged from complete disappearance in human

diets to irregular consumption by mainly elderly or people who lacked alternative food sources. Parallel to this change, the species' pulps were increasingly used as an animal feed. For *B. aegyptiaca* pulps, consumption levels showed high variation in the research area some decades ago. Whereas a part of the research sample regularly consumed the pulps during their childhood, others completely lacked consumption during their youth. The pulps were traditionally consumed raw. In recent times, preparation of pulps for porridge and processing into juices came along. As for *B. aegyptiaca* pulps, people who regularly frequented the bushlands had currently higher consumption levels of *D. microcarpum*'s pulps. The stop of storage activities of *D. microcarpum*'s fruits in granaries at presence indicated their strong decline in consumption. Whereas the species fruits lost their importance for dietary consumption, use of *D. microcarpum*'s wood increased over the last decades.

5.2.3. Varying trend in consumption

Consumption of the remaining six investigated plant parts showed non-uniform patterns. For *A. digitata's* leaves, positive, negative, and unchanged developments of consumption were mentioned while the leaves' commercialization level increased over the last decades. Others stated that consumption increased only slightly or even decreased, as the leaves were already highly consumed in the past. Following a similar pattern, *A. digitata*'s kernels had varied changes in consumption. The transformation of *A. digitata*'s kernels into oil represented a new way of consumption beside their consumption in sauces. A long tradition had the consumption of a fermented paste made from *P. biglobosa*'s seeds. However, the fermented paste was partly substituted by bouillon cubes approximately one decade ago. Although this trend was partly reversed during recent years, a part of the respondents stated changed preparation by mixing the fermented paste with purchased food such as bouillon cubes or canned tomatoes or declines in consumption due to increased sale's level. Another part of respondents indicated that the seeds were increasingly harvested from both own production and from the wild, as well as used for own consumption and marketing in the research area. For some of the respondents, consumption remained unchanged, as they had consumed the fermented paste daily since their childhood. Whereas *P. biglobosa*'s seeds had currently high consumption levels, seeds of *H. sabdariffa* were nowadays little or non-consumed. In contrast, consumption of *O. gratissimum's* leaves were at an inexistent or low-level during the respondent's youth. Current consumption was limited to a minority of the local population, but with various stated developments over time. Also, *B. sapida*'s arils showed a high variation in their change over time ranging mostly from clearly positive to clearly negative changes in their consumption.

5.3. Drivers for changes in consumption of the selected NUS

Multidimensional drivers within the personal food environment were identified with contributing, neutral, and counteracting influences on consumption of the plant parts assigned to the three main trends. The dimension of accessibility was co-responsible for the decreased consumption of the plant parts with the downward trend, whereas with the two other trends, contributing and counteracting influences were stated. Affordability had no enhancing effects on consumption of all investigated plant parts over time. Changes in convenience had non-uniform influences on the three main trends and contributed to both the increasing and decreasing trend of some plant parts. Also, different aspects of desirability were contributing and counteracting consumption, as for instance an increase in food and nutrition knowledge and skills contributed to the upward trend of the respective plant parts. A more detailed overview of the change and influence of each aspect on the consumption of the corresponding plant part is provided (Annex 13.6).

In the following subchapters, the identified drivers which were related with the three consumption trends of the respective plant parts are presented.

5.3.1. Influences on the increasing consumption trend

Several aspects of desirability contributed to the positive trend in consumption, mainly in form of increased food and nutrition as well as biological and ecological knowledge and skills and sensory preferences (Figure 4). In contrast, informal institutions had only counteractive effects on the positive trend, whereas social markers remained mostly without influence. Furthermore, changes in accessibility were both contributing and opposing the positive trend in consumption, whereas the dimensions of affordability and convenience were not responsible for the increase in consumption of the respective plant parts.

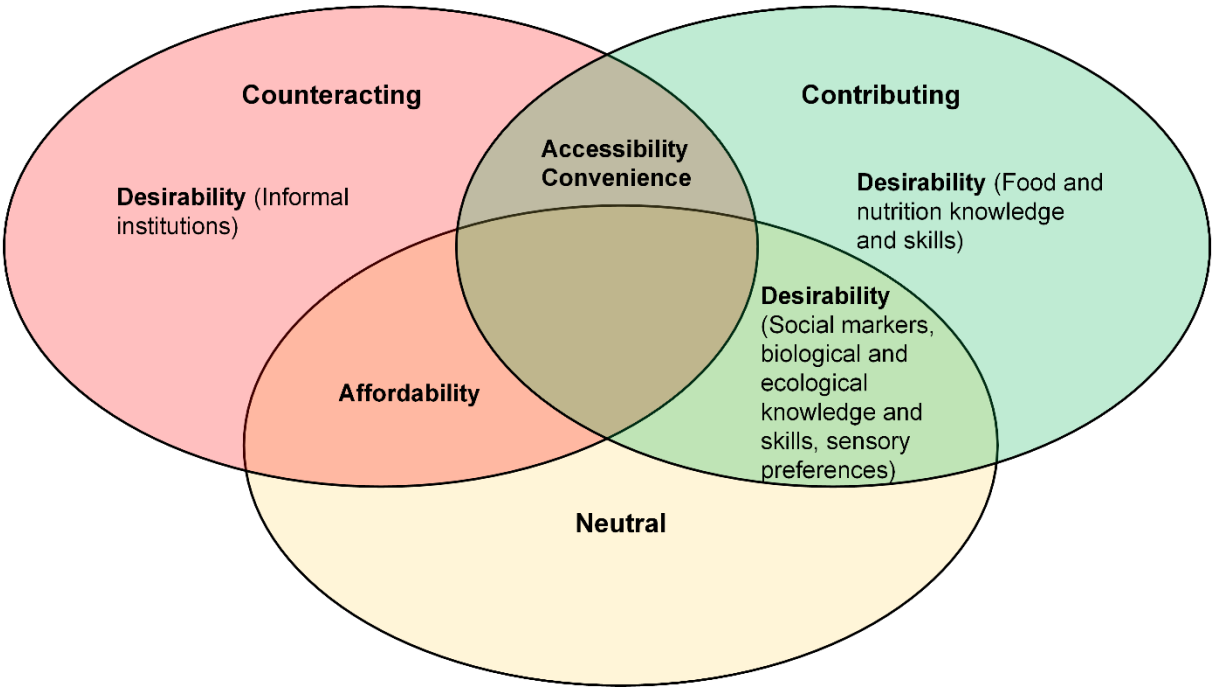


Figure 4 Influences of the dimensions of the food environment on the increasing trend in consumption

Among the five plant parts with an increasing consumption trend (*C. gynandra H. sabdariffa*'s calyces and leaves, *M. oleifera*, *V. radiata*), the aspect of food and nutritional knowledge and skills was most uniformly positively related with consumption. Increased awareness about the plant parts' usefulness, mainly regarding health and nutrition as well as new processing, storage and preparation techniques were stated. For *C. gynandra* and *M. oleifera*, the increase in the level of knowledge and skills was most significant. Although these species existed for a long time in the research area, information about the edibility and usefulness of their leaves was unknown during most of the research sample's youth. For *M. oleifera*, some respondents knew about the leaves' edibility but consumed them at a low level compared to now. Indeed, the leaves were partly also used as animal fodder during the interview partners' youth. The information about *M. oleifera*'s leaves' usefulness for nutrition and health was enhanced through promotion activities of different stakeholders, including local projects, hospitals, scientists, start-ups, or mass media. Their activities sensitised the local population about *M. oleifera*'s usefulness for food by recommending the leaves as part of a recovery diet of malnourished children, by marketing of products based on the species' leaves or by information campaigns. Moreover, new processing, storage and preparation techniques, including the transformation of plant parts into juices *(H. sabdariffa*'s calyces), storage of plants parts in form of powder of leaves (*M. oleifera*) or dried calyces (*H. sabdariffa*), or new ways of preparation (*C. gynandra*) contributed to their increased consumption.

A further aspect of desirability, preferences for sensory properties, remained unchanged but contributed to the positive change in consumption of three of the plant parts with an upward

trend (*H. sabdariffa*'s calyces and leaves, *M. oleifera*). For instance, the acid taste of *H. sabdariffa*'s plant parts were particularly appreciated. A further aspect, the level of biological and ecological knowledge and skills was for two of the five plant parts, at least party contributing to the positive consumption trend. As for instance *M. oleifera* became increasingly cultivated in home gardens. Initiation of human-induced reproduction by local population also increased consumption of leaves of *C. gynandra*. Seeds of *C. gynandra* were collected and kept for sowing. For *H. sabdariffa*, unchanged cultivation and management techniques such as fire protection enabled consumption in former and current times. Almost without influence on the increasing consumption trend was the aspect of social markers with exception of the partly increased positive markers related to *M. oleifera*'s consumption. *M. oleifera*'s image changed from a foreign to a more familiar and appreciated part of the human diet.

Informal institutions were the only aspect of desirability which made some of the plant parts' consumption less desirable. A decrease in social access was stated, as some of the plant parts were less transferred for free among households knowing each other, e.g. among neighbours of the same village. For instance, regarding *M. oleifera*'s leaves, non-monetary transfers became less common, which decreased the access to the leaves for individuals and households lacking the leaves from other sources of acquisition. Also, the dimension of affordability, was never linked to an increase in consumption. In contrast, *M. oleifera*'s leaves and partly *V. radiata*'s seeds became less affordable with negative to neutral influences on their consumption.

Furthermore, the dimensions of accessibility and convenience had contrasting influences on the upward trend. Particularly accessibility was for each plant part simultaneously an enhancing and impeding factor for consumption. Improved accessibility was reached through an increase or the emergence of own cultivation practices. Several species were started to be cultivated for instance in home gardens (*C. gynandra, M. oleifera*), although the increased amount of harvest did not necessarily lead to an increased consumption level. Sources of acquisition were also substituted, when with increased self-supply, the purchase level of *M. oleifera*'s leaves diminished. Nevertheless, a part of respondents perceived no change in accessibility of *M. oleifera*, as the species' trees were already present in proximity, growing on fields and around houses approximately two decades ago. Another reason for *M. oleifera*'s increased consumption was the decreasing accessible range of alternative food sources. With exception of *A. esculentus* (ocra) during the dry season, not many accessible alternative leafy vegetables for *M. oleifera* existed. On the other hand, the plant parts whose consumption had a medicinal purpose were increasingly substituted by non-plant-based medicine (*H. sabdariffa*). For *V. radiata*, its accessibility depended highly on the availability of seeds for cultivation of the annual species. Regarding, convenience, alternative food products also influenced *H. sabdariffa*'s calyces' consumption, which were perceived as less convenient than artificial aromas used in the processing to juices. For *V. radiata*, the lack of storage facilities at the harvest period, which usually took place at the end of the rainy season, reduced the seeds' consumption. Some years ago, with the arrival of a new variety of *V. radiata* convenience became higher because of its shorter production cycle, bigger seeds as well as shorter preparation time.

5.3.2. Influences on the decreasing consumption trend

For the plant parts with the main decreasing trend in consumption, there were no solely counteractive influences (Figure 5). All dimensions of the personal food environment partly or in case of accessibility solely contributed to the plant parts' decreasing trend. Only the dimension of convenience and some aspects of desirability (food and nutrition knowledge and skills and sensory preferences) were partly opposing the decline.

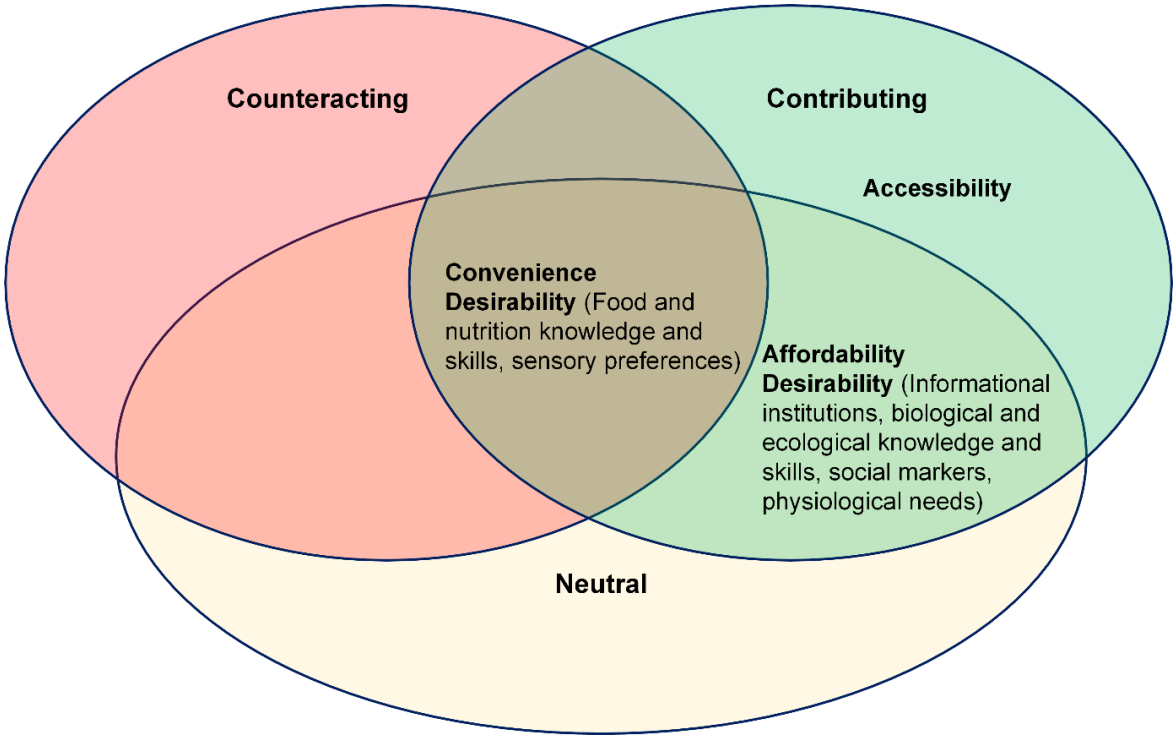


Figure 5 Influences of the dimensions of the food environment on the decreasing trend in consumption

The dimension of accessibility contributed most uniformly to the main decreasing trend in consumption among the five plant parts with a downward trend (*A. digitata*'s pulps, *B. aegyptiaca*, *D. microcarpum*, *P. biglobosa*'s pulps, *T. indica*). These plant parts became less accessible and consumed due to several reasons including land-use changes combined with low potential for natural reproduction and inexistent or low human-induced reproduction levels. Three of the five species lacked human-induced reproduction (*B. aegyptiaca*, *D. microcarpum*, *T. indica*), whereby unsuccessful reproduction trials were mentioned for *T. indica*. For the partly cultivated perennial species, low reproduction levels had underlying causes such as low financial incentives for the species' wood production compared to other species (*P. biglobosa*) or the long time needed until the trees bear fruits for the first time (*A. digitata*). Other changes in accessibility were more subtle, as for instance infrastructures such as schools were built in shorter distances and led to shorter ways to school while wild species were increasingly pulled back into the bushlands (*B. aegyptiaca*, *D. microcarpum*, *P. biglobosa*). Fruits-producing trees of *D. microcarpum* were predominantly existing in long distance (e.g. 30-40 km) of villages nowadays. Especially for people at a higher age, these trees were no longer accessible. Furthermore, for *D. microcarpum* and *B. aegyptiaca*, the possibilities for market-based acquisition of their fruits partly decreased because of a decline in demand. In addition, the increased production of a variety of alternative food sources decreased consumption of some species (*A. digitata*'s *pulps, D. microcarpum*, *P. biglobosa's pulps)*. The research sample depended less on the wild harvest of these fruits as they substituted them by the production of other plant species such as *Dioscorea* L. (yams), *Oryza sativa* L. (rice), *Glycine max* (L.) (soja) or *V. radiata* (mungbean). In line with the findings for some plant parts with the upward trend, consumption of *T. indica's* pulps for medicinal purposes declined and was replaced of medicinal products from Western countries.

Regarding the desirability of these plant parts, informal institutions in terms of decreased social access regarding harvesting and transfers contributed to the downward trend of several plant parts (*A. digitata*'s pulps, *P. biglobosa*'s pulps, *T. indica*). For instance, free harvest of *P. biglobosa*'s pods became increasingly regulated through the growing demand for the species' seeds. In addition, rules which protected perennial species such as *P. biglobosa* and *T. indica*

from cutting became increasingly neglected. The social markers assigned to the consumption of the plant parts were at least partly a reason for their decline (with exception of *A. digitata*'s pulps). The clearest shift was found for *P. biglobosa*'s pulps, whose consumption was increasingly perceived as a marker of poverty. During the local experts' youth, the pulps were considered as a staple food, which was mainly consumed during fieldwork and time of food shortages. Over time, consumption of the pulps was increasingly interpreted as a sign of being out of food stocks. Higher quantities of pulps were no longer consumed and began to rotten at a certain moment. Instead of throwing them away, they were fed on animals. Observing animals eating the pulps increased the emotional distance to this food. Moreover, the increased substitution by sugar, which was socially assigned to more positive attributes, diminished the consumption of pulps. Thus, consumption of the pulps became related with negative attributes such as old-fashioned and perceived as famine food and animal feed. For other species such as *D. microcarpum*, the valuation shifted from the fruits to the species' wood. This was explained by the low transmission of the value of the species for food consumption from elder to younger generations. A part of respondents also perceived no changes of *D. microcarpum*'s social markers, but consumption nevertheless became less over time.

Regarding the dimension of affordability, pulps of *A. digitata* and *T. indica* became less affordable for auto-consumption through their increased economic value and market-based transactions, whereas *B. aegyptiaca*'s and *D. microcarpum*'s proportion on market-transfers remained low. While *P. biglobosa*'s seeds gained in economic value, the non-existent sales market for the pulps reduced their consumption. The harvesting period of pods was furthermore increasingly adapted to the best point of harvest for the species' seeds. This was at a stage when the pulps were still partly immature. Moreover, all plant parts with a decreasing trend in consumption were at least partly connected to a loss in biological and ecological knowledge and skills. *B. aegyptiaca* and *D. microcarpum* became less known by a part of the local population while disappearing physically in the people's surroundings. Another reason for decreased consumption was a loss of reproduction and maintenance knowledge and skills (*P. biglobosa*, *T. indica*).

The only partly counteracting influences on the decreasing consumption trend came from the dimension of convenience and desirability-related aspects in terms of food and nutrition knowledge and skills, sensory preferences, and physiological needs. But convenience-related aspects also partly decreased consumption of *P. biglobosa*'s and *D. microcarpum*'s pulps due to their increasingly difficult harvest in the bushland, where herbs growing around the trees, longer transports of the harvested amounts combined with a lack of sufficient family workforce made the work more difficult. Moreover, decreased time available and higher preferences for purchasing rather than cultivating food sources prevented young people to cultivate new trees. For *D. microcarpum* for instance, perceived time and effort needed for consumption increased over time and exceeded the benefits from consuming its pulps. Changes in the food and nutrition knowledge and skills, had for some of the plant parts only negative (*B. aegyptiaca*, *D. microcarpum*, *P. biglobosa*'s pulps), but for others also partly positive effects (*A. digitata*'s pulps, *T. indica*). Positive effects were related to the increased awareness of health and nutrition benefits and new processing methods such as transformation into juices. On the other hand, storage techniques of *P. biglobosa*'s pulps were less transmitted to the younger generation. In addition, a loss of familiarity and changes of dietary habits were contributing to the decline in consumption (*A. digitata*'s *pulps, B. aegyptiaca*, *D. microcarpum*, *P. biglobosa's pulps*). For instance, mothers and grandmothers were used to prepare porridges with pulps of *A. digitata* or *P. biglobosa* which nowadays stopped. Also, a decrease in sensory preferences was with exception of *T. indica* partly a reason for the decline in consumption, related to unfavorable taste perceptions such as sour (*A. digitata*, *P. biglobosa*) or missing flavour (*D. microcarpum*) of pulps. Also decreased physiological needs were one explanatory factor for some of the plant parts' decline (*A. digitata*'s pulps, *P. biglobosa*'s pulps, *T. indica*), because they were for instance less used to deal with hunger and strenuous work.

5.3.3. Influences on the varying consumption trend

For the plant parts with the mainly varying consumption trend, the influences of the different dimensions and aspects of their food environment were mostly non-uniform (Figure 6). All dimensions of the personal food environment had simultaneously at least both positive and negative (partly also neutral) influences on the changes in consumption. Accessibility and convenience both reduced and enhanced consumption, whereas most aspects of desirability had furthermore neutral effects. Only the dimension of affordability and the aspect of informal institutions ranged from solely negative to neutral effects.

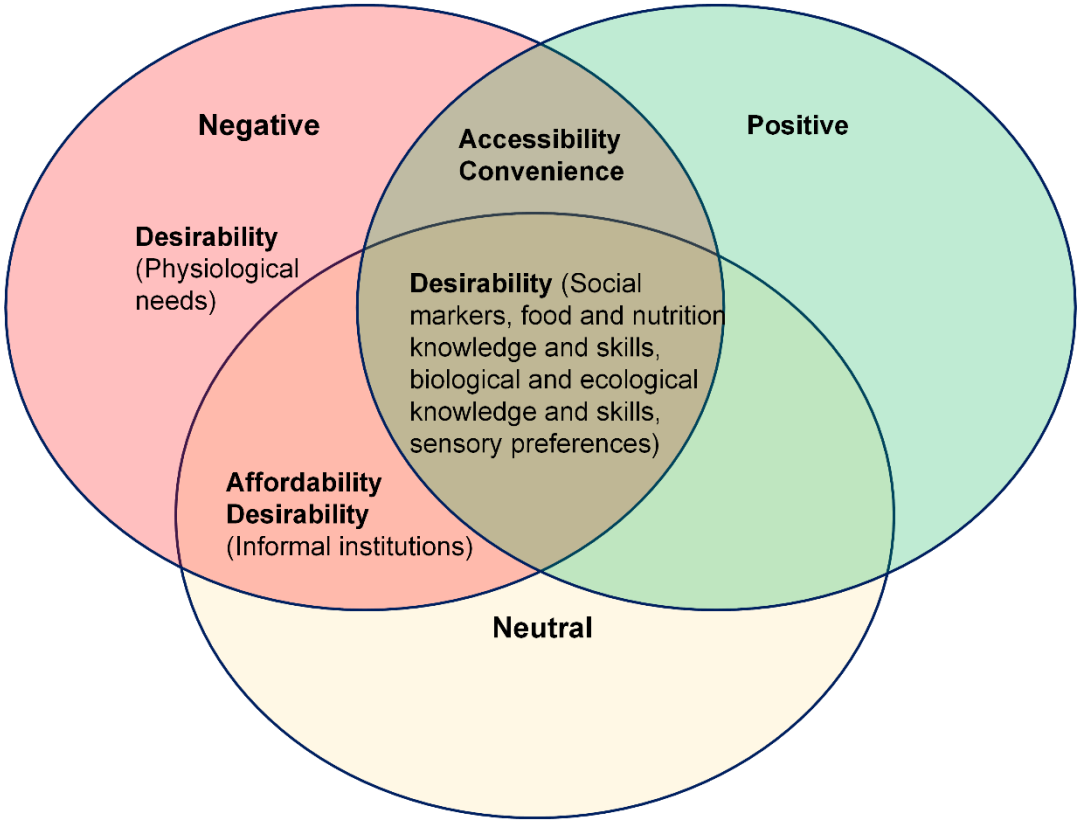


Figure 6 Influences of the dimensions of the food environment on the varying trend in consumption

Among the plant parts with the varying trend (*A. digitata*'s leaves and kernels, *B. sapida*, *H. sabdariffa*'s seeds, *O. gratissimum*, *P. biglobosa*'s seeds) there exists an overriding tendency of negative influences. Regarding affordability, the increasing sale's level of *A. digitata*'s leaves, *B. sapida* and *P. biglobosa*'s seeds negatively affected the auto-consumption by the research sample. For instance, the fermented paste made from *P. biglobosa*'s seeds was increasingly sold and replaced by the more affordable fermented paste made from *Glycine max* (L.) (soja). In line with the changes in affordability, informal institutions through decreased social access had negative effects on consumption of three plant parts (*A. digitata*'s leaves, *B. sapida*, *P. biglobosa*'s seeds). Furthermore, physiological necessity for consumption of one of the plant parts decreased with age of the respondents and the increasing alternative of other food sources (*A. digitata*'s leaves).

All plant parts became in some respects more, in others less accessible, convenient, and desirable. Regarding the accessibility, for instance *B. sapida*'s trees were found in every household during some of the respondents' youth and decreased to one or two species per village. Others reported that *B. sapida*'s and other species' accessibility through harvest from own cultivation raised for several years (*B. sapida*, *H. sabdariffa*). Furthermore, consumption of arils of *B. sapida* and *P. biglobosa* seeds became less convenient, whereas positive and negative effects were stated for *A. digitata*'s leaves and kernels. Unchanged high convenience

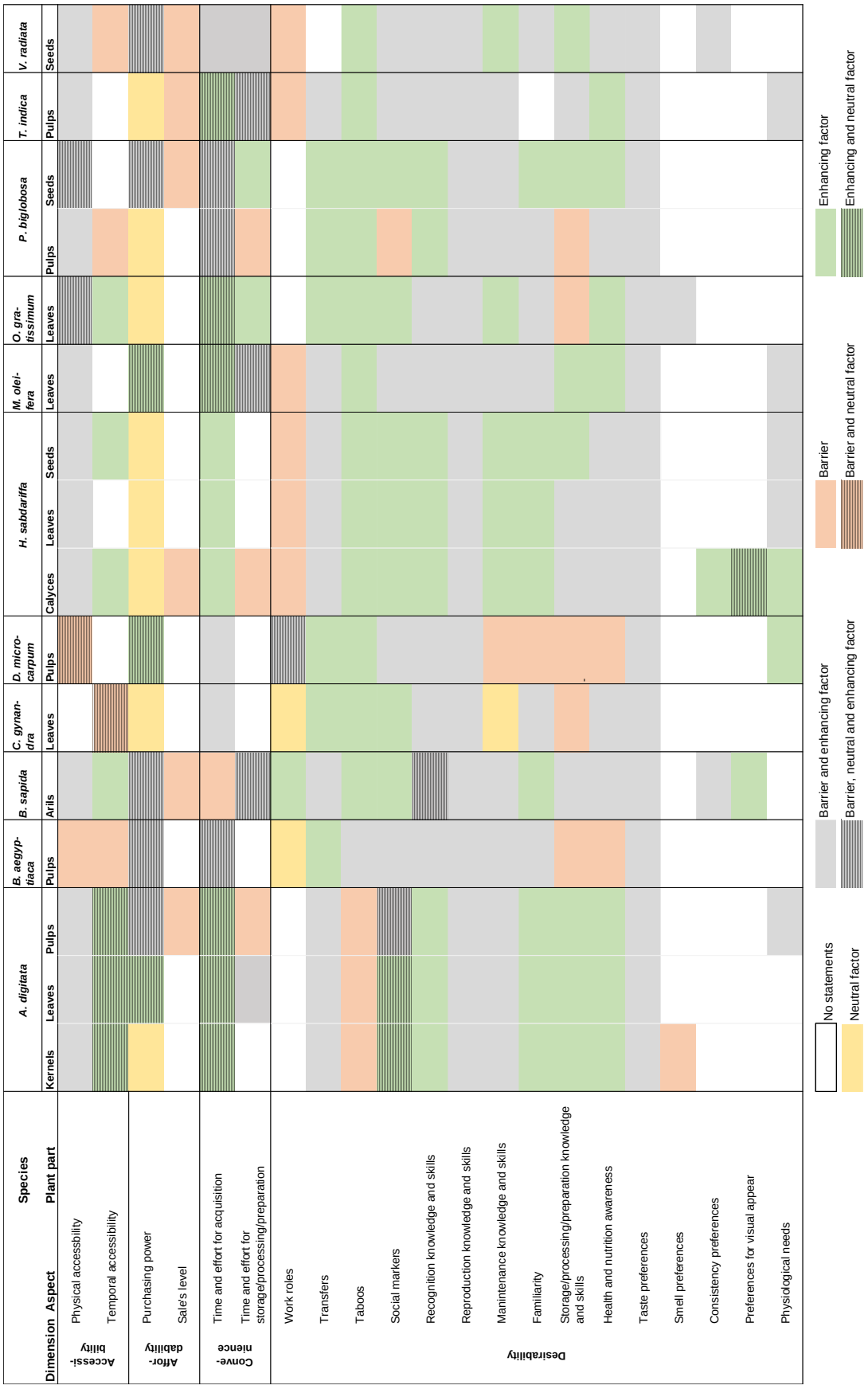
regarding the preparation of *A. digitata*'s plant parts in terms of easy and fast cooking increased consumption. Also, further aspects of desirability had various influences on the plant parts' consumption. Sensory preferences affected their consumption positively (*H. sabdariffa*'s kernels, positively and negatively (*B. sapida*) or negative and neutrally (*O. gratissimum*). The strong smell of *O. gratissimum*'s leaves were partly outweighed by the increased awareness of their health and nutrition benefits. Social markers were only for two of the plant parts decisive for their change in consumption (*B. sapida*, *P. biglobosa*). A decreased consideration of food products from perennial species was stated. They were increasingly perceived as old-fashioned and preferences for western-oriented diets decreased their consumption. Originally, trees of *B. sapida* were planted for obtaining shade in the courtyards of houses of the ethnic groups Waama and Otamari and were particularly culturally important for them. However, for some respondents the lack of reproduction and not decreased appreciation of the arils was the main reason for changes in its consumption. For *P. biglobosa*, growing orientation towards western diets led to the increased substitution of fermented paste by bouillon cubes. Women who cooked without bouillon cubes were socially considered as bad cooks. But approximately one decade ago, the value and use of the fermented paste was rediscovered. Food and nutrition as well as biological and ecological knowledge and skills had varied influences on the plant parts' consumption. Leaves of *A. digitata* were for instance increasingly stored in form of powder and consumed for an extended period. The influence of ecological knowledge and skills ranged from neutral to positive (*A. digitata*'s leaves), only neutral (*A. digitata*'s kernels, *H. sabdariffa*'s seeds), neutral, negative and positive (*B. sapida*, *O. gratissimum*), to neutral and negative effects (*P. biglobosa*'s seeds). Stakeholders from NGO's promoted *A. digitata*'s reproduction by planting their seedlings in home gardens which enabled regular harvest of leaves. Furthermore, reproduction effects partly increased for *B. sapida* and *O. gratissimum*, whereas other respondents perceived a loss of reproduction and maintenance knowledge and skills including for *P. biglobosa*. For others, on the other hand, no changes in maintenance, like ongoing protection on fires enabled consumption in former and current times (*B. sapida*, *H. sabdariffa*, *P. biglobosa*).

5.4. Barriers and enhancing factors for consumption of the selected NUS

Most plant parts had various barriers and enhancing factors regarding all four investigated dimensions of the personal food environment (Table 13). For some plant parts, specific aspects represented solely barriers (marked in red) or enhancing factors (marked in green), whereas for others, the same aspect had both impeding and enhancing influences (marked in grey) on consumption. In addition, some of the investigated aspects had also mentioned neutral effects on consumption (marked in yellow/indicated by dashes).

In the following subchapters, the barriers, neutral and enhancing factors related to each dimension of the personal food environment are discussed.

Table 13 Barriers and enhancing factors for consumption of the investigated NUS' plant parts



5.4.1. Accessibility

Physical and temporal aspects of accessibility had an influence on all plant parts' consumption. Barriers and enhancing factors (Table 14) regarding the plant parts' physical accessibility were determined by the abundance of the plant parts in the local natural and built environment. The seasonal patterns of the plant parts' availability and their extension through processing and storage activities over the year described their temporal accessibility.

Table 14 Barriers and enhancing factors for consumption of the dimension of accessibility

Dimension and its aspects	Barriers for consumption	Enhancing factors for consumption
Accessibility	Low physical accessibility • No or low availability in the natural environment and not sufficently accessible in the surroudings • Low productivity and harvested yields • Lack or limited genetic material • Lack of cultivable land and/or space for natural reproduction • High destruction rates (e.g. due to prioritisation of the species' wood, other cash crops) • Low presence on markets	High physical accessibility • High abundance in the natural environemnt and highly accessible from wild/cultivated areas • High presence on markets and highly accessible through market-based transfers
	Low temporal accessbility • Lack or limited access to water for cultivation • Lack or limited storage and processing	High temporal accessibility • Accessible year-round (e.g. through • Higher accessibility than alternatives

5.4.1.1. Physical accessibility

For none of the species, solely high physical accessibility was mentioned. Low physical accessibility was perceived solely as a barrier for consumption of the pulps of two wild growing species (*B. aegyptiaca*, *D. microcarpum*). These species were mainly growing in the bushland with a varied abundance among the three communes of the research area. *B. aegyptiaca*'s presence was perceived to be higher in the commune of Tanguiéta than in Natitingou and Toucountouna. Fruit bearing trees of *D. microcarpum* were generally rare to find. In some of the research villages, these species were not accessible at all which prevented their consumption. Reasons for their low physical accessibility included destruction by bush fires or cutting combined with lack of reproduction efforts and low yields.

The remaining nine species' plant parts had varied levels of physical accessibility. Four of the woody species' plant parts were harvested from short distances in the wild and/or cultivated within the villages' surroundings (*A. digitata*, *B. sapida*, *P. biglobosa*, *T. indica*). Their partly low accessibility was due to non-existent (*T. indica*) or insufficient reproduction efforts by humans (*A. digitata*, *B. sapida*, *P. biglobosa*) combined with a decreased productivity of elder trees. Moreover, these perennial species were destroyed by cutting or bushfires. Several species lacked accessible space for their production (*B. sapida*, *H. sabdariffa*, *M. oleifera*, *V. radiata*) and genetic material in the case of the solely cultivated species (*H. sabdariffa*, *M. oleifera*, *V. radiata*). Prioritised cultivation of cash crops such as cotton, whose production was politically subsidised, decreased the available surface for these species' cultivation. Underlying factors of destruction and lack of (re)production was a mentality based on short-term profits from the marketing of the perennial species' wood and the sale of cash crops. Herbs like *C. gynandra* and *O. gratissimum* were accessible through their wild and cultivated growth around houses.

Not all plant parts' low physical accessibility in the natural environment could be replaced through market-based acquisitions. High presence on local markets in respondents' accessible radius was enhancing the consumption of several plant parts (*A. digitata*'s fruits and leaves, *B. sapida*, *P. biglobosa*'s seeds, *T. indica*). In contrast, some plant parts were only to a limited

extent (*B. aegyptiaca*, *D. microcarpum*, *M. oleifera*, *V. radiata*) or not at all (*C. gynandra*) accessible from markets. Mentioned reasons for the low presence on markets was the low commercialised supply (*B. aegyptiaca*, *D. microcarpum*, *V. radiata*) or the comparable high demand (*M. oleifera*).

5.4.1.2. Temporal accessibility

Annual leafy vegetables were mainly accessible during the rainy season, whereas fruits and seeds ripened during the dry season. Storage and processing extended the consumption period to the whole year for some plant parts (*H. sabdariffa*'s calyces and seeds, *M. oleifera*, *P. biglobosa*'s seeds). For others, only limited (*P. biglobosa*'s *pulps, V. radiata*) or no (*B. aegyptiaca*, *C. gynandra*, *D. microcarpum*) processing and storage activities were conducted and limited these plant parts' consumption. Thus, *B. aegyptiaca*'s and *D. microcarpum*'s fruits were only consumed during dry season and *C. gynandra*'s leaves at the beginning of the rainy season. Difficulties in storage led for instance back to unfavourable weather conditions during the rainy season and insufficient storage facilities (*C. gynandra*, *P. biglobosa*'s pulps, *V. radiata*). For remaining plant parts' temporal accessibility over the year depended on the level of processing and storage activities (*A. digitata*, *B. sapida*, *H. sabdariffa*'s leaves, *T. indica*).

5.4.2. Affordability

Aspects related to affordability in terms of purchasing power and sale's level were reducing and enhancing consumption (Table 15). Generally, patterns of purchase and sale highly depended on the acquired yields from cultivation and wild collection. For all plant parts, the natural environment was the main source of acquisition. According to the proportion of supply and demand, prices of all commercialised species were undergoing a seasonal variation. A part of the plant parts had no barriers related to the dimension of affordability (*A. digitata*'s kernels and leaves, *C. gynandra*, *D. microcarpum*, *H. sabdariffa*, *M. oleifera*, *O. gratissimum*).

Table 15 Barriers and enhancing factors for consumption of the dimension of affordability

Dimension and its aspects	Barriers for consumption	Enhancing factors for consumption
Affordability	Low purchasing power • Unaffordable prices • Subsititued by more affordable options Low or high sale's level • Sale in detriment of own consumption • Poorly developped markets	High purchasing power • Affordable prices • Purchase indepedent from financial resources

5.4.2.1. Purchasing power

The purchasing power was no barrier for the acquisition of four plant parts (*A. digitata*'s leaves, *D. microcarpum*, *M. oleifera*, *O. gratissimum*), while preventing or partly reducing purchase and consumption of five other plant parts (*A. digitata*'s pulps, *B. aegyptiaca*, *B. sapida*, *P. biglobosa*'s seeds, *V. radiata*). Although the latter plant parts were mentioned to be bought to compensate low yields or depleting stocks, consumption by purchase was on a comparable moderate level. Some plant parts were also substituted by more affordable options, such as the fermented paste made from *P. biglobosa*'s seeds which was replaced by more affordable seasonings (e.g. paste made from soja or by bouillon cubes) or *V. radiata*'s seeds by cheaper legumes (e.g. cowpea).

Neutral influences of the purchasing power were rooted in the partly disconnection of the plant parts' acquisition from monetary resources. Reasons for this were sufficiently acquired amounts of the plant parts from the natural environment (*B. aegyptiaca*, *C. gynandra*, *D. microcarpum*, *H. sabdariffa*, *M. oleifera*, *O. gratissimum*, *P. biglobosa*, *V. radiata*), from free transfers (*A. digitata*, *B. aegyptiaca*, *B. sapida*, *C. gynandra*, *D. microcarpum*, *H. sabdariffa*, *O.*

gratissimum, *M. oleifera*, *T. indica*) or through a purchasing behaviour which was decoupled from financial resources (*A. digitata*, *P. biglobosa*'s seeds, *T. indica*).

5.4.2.2. Sale's level

Edible plant parts with a high economic value were commercialised if acquired in bigger quantities from the natural environment. Negative effects of high sale's levels on auto-consumption were mentioned for six plant parts (*A. digitata*'s *pulps, B. sapida*, *H. sabdariffa*'s calyces, *M. oleifera*, *P. biglobosa*'s seeds, *T. indica*). Monetary income from the sale of these plant parts was used to buy food (e.g. staple crops, condiments) and other items (e.g. soap, laundry, shoes, clothes). Furthermore, *H. sabdariffa*'s calyces and *P. biglobosa*'s seeds were often sold to buy their processed products (juice of *H. sabdariffa*, fermented paste of *P. biglobosa*). Reasons for this were the lack of physical, financial, and human assets for their transformation. Seeds of *P. biglobosa* were also often traded which could represent a lucrative activity. Lack of sales markets lowered production levels of *V. radiata* because costs for production were perceived to exceed the benefits.

5.4.3. Convenience

Barriers and enhancing factors related to the dimension of convenience were determined through the relative time and effort needed for the acquisition, processing, storage, and preparation for the plant parts' consumption (Table 16). These convenience-related aspects were not perceived as a barrier for consumption for some of the plant parts (*A. digitata*'s kernels and leaves, *H. sabdariffa*'s leaves and seeds, *M. oleifera*, *O. gratissimum*).

Table 16 Barriers and enhancing factors for consumption of the dimension of convenience

Dimension and its aspects	Barriers for consumption	Enhancing factors for consumption
Convenience	Unconvenient acquistition	Convenient acquisition
	• Long distances to overcome	• Short distances to overcome
	• Specific plant properties (e.g. thorns, little size of seeds, height of trees, fast bursting of pods)	
	• Parallel high workload for other crops	
	Unconvenient processing, storage and preparation	
	• Limited time resources for post-harvest activities	
	• Lack or limited material and additives for processing	
	• Unfavourable weather conditions for storaging	
	• Lack or limited storage facilities, packaging and high rottening rates	
	Unconvenient preparation	Convenient preparation
	• Long cooking time	• Short cooking time

5.4.3.1. Acquisition

High convenience regarding the plant parts' acquisition was reported for four species (*H. sabdariffa*, *M. oleifera*, *O. gratissimum*, *T. indica*). These plant parts were easily acquired from the natural environment which enhanced their consumption. In contrast, a particular barrier represented the inconvenient acquisition of the fruits of *B. sapida*'s which often rotted at an immature state on the trees. For the remaining plant parts, the level of convenience varied from low to high with contrasting effects on their consumption (*A. digitata*, *B. aegyptiaca*, *C. gynandra*, *D. microcarpum*, *P. biglobosa*, *V. radiata*). Reasons for inconvenient harvesting included specific plant properties such as big height of trees (*A. digitata*), thorns (*B. aegyptiaca*), little size of seeds (*C. gynandra*) and extended maturation, fast bursting of mature pods, little seeds, itchy hairs (*V. radiata*). Further reasons were linked to long distances to overcome

(*D. microcarpum*) or parallel high workload for other cultures (*P. biglobosa*, *V. radiata*). A part of respondents for instance reported lack of time for wild harvesting of *D. microcarpum*'s fruits, whereas for those who were making these ways anyways the distances to overcome were no barrier. Woods properties such as the lightness and good burning qualities of *D. microcarpum*'s trees supported its utilisation as firewood with negative side-effects on their fruits' consumption.

5.4.3.2. Processing, storage, and preparation

For several plant parts, inconvenient processing and storage was a barrier for consumption (*A. digitata*'s *pulps, B. sapida*, *C. gynandra*, *H. sabdariffa*'s calyces, *P. biglobosa*'s *pulps, T. indica*, *V. radiata*). In general, limited time resources to manage the high workload was the main reason for the inconvenience. Furthermore, there was often a lack of material inputs (e.g. refrigerator, additives such as sugar clean water, bottles) to process and store raw products (*A. digitata*'s *pulps, H. sabdariffa*'s calyces, *P. biglobosa*'s seeds). For instance, the sampled rural population usually prepared the juice of *H. sabdariffa* themselves for special occasions, whereas otherwise they purchased it on markets. Due to unfavourable storage conditions, *V. radiata*'s production cycle was for instance often timed towards the end of rainy season to avoid humid conditions. Furthermore, difficulties in packaging and attacks by insects of the stored products were reducing some plant parts' consumption (*B. sapida*, *T. indica*).

Preparation of six plant parts was found to be highly convenient due to the short amount of time needed (*A. digitata*' leaves, *B. sapida*, *C. gynandra*, *O. gratissimum*, *P. biglobosa*'s seeds, *V. radiata*). Nevertheless, old leaves of *A. digitata* were for instance avoided and an older variety of *V. radiata*'s seeds was less preferred because they were associated with longer cooking times. No influence of preparation time and effort was found for two plant parts (*M. oleifera*, *T. indica*). The relatively long time for removing *M. oleifera*'s leaves due to their little size had no negative influence on consumption. Also, the time expenditure for the dilution of fruits of *T. indica* in water before the consumption remained without impact.

5.4.4. Desirability

The dimension of desirability consisted of several aspects (informal institutions, social markers, knowledge and skills related to the biology and ecology as well as to food and nutrition, sensory preferences and physiological needs) related to the consumption of the investigated NUS. Within each of these aspects, there were specific barriers and enhancing factors for each plant part. The emerging topics over all investigated plant parts were summarised (Table 17) and discussed in-depth in the following subchapters.

Table 17 Barriers and enhancing factors for consumption of the dimension of desirability

Dimension and its aspects	Barriers for consumption	Enhancing factors for consumption
Desirability		
Informal institutions	Unfavourable conducts of behaviour • Low acceptance for existing species by men • Releasement of livestock for free grazing • Restriced or lack of free transfers among neighbours • No rules to protect species from contanimation • Taboos for reproduction and consumption	Favourable conducts of behaviour • Shared harvest • Free transfers among neighbours • Lack of taboos and consumption by everyon
Social markers	Low appreciation • Negative associations (e.g.famine food, animal food, food for the poor, food for children, foreign species)	High appreciation • Positive associations (e.g. famine food, part of local food culture, cultural importance of species) • Consumption at specific occasions (e.g. festivities) • Consumption for medicinal purposes
Biological and ecological knowledge and skills	Low recognition • Lack of recognition • Destruction through unfamiliarity	High recongition • High familiarity
	Low reproduction by humans • Lack or limited knowledge and skills about reproduction techniques • Belief in only natural reproduction and lack of interest and incentives for reproduction	High reproduction by humans • High knowledge and skills about reproduction techniques
	Low maintenance • Lack of maintenance • Lack of available water • Lack of plant protection from pests and diseases	High maintenance • Weeding and protection from fires • Regular watering • Protection from grazing animals
Food and nutrition knowledge and skills	Low familiarity • Lack of knowledge about edibility (e.g. through less time spent in the bushlands)	High familiarity • Transmission of consumption habits (e.g. consumed during school breaks)
	Low processing and storage skills • Bad storage practices (e.g. drying in the sun, unclean storage places) • Short shelf-life	High processing and storage skills • Various processing and storage techniques • Long shelf-life
	Low health and nutrition awareness • Lack or limited information on health benefits and nutritive values • Belief that consumption makes ill	High health and nutrition awareness • Consumption for medicinal purposes and well-being
Sensory preferences	Low taste preferences • Too sugary or acid, bitter, lack of taste • Strong, unpelasant smell • Subsitution by more tasteful food sources • Unfavourable consistency after cooking	High taste preferences • Sugary or acid taste • Reduction of undesirable taste or smell of
Physiological needs	Low physiological needs • Low satisfaction of hunger • Appetising effects • Lack of consumption when suffering from ulcers	High physiological needs • Thirst-stilling or hunger-calming effects • Appetising effects

5.4.4.1. Informal institutions

Informal institutions included the work roles, conventions about non-monetary transfers as well as specific taboos related with consumption. The distribution of work roles was either perceived as barrier or as irrelevant for consumption. In contrast, informal institutions about transfers of plant parts had various positive and negative effects. The lack of taboos for most species was perceived to enhance their consumption. Five plant parts of four species were not affected by barriers in informal institutions (*C. gynandra*, *D. microcarpum*, *O. gratissimum*, *P. biglobosa*).

Work roles

A solely negative effect of labour division on consumption was mentioned for four species (*H. sabdariffa*, *M. oleifera*, *T. indica, V. radiata*). The acceptance to cultivate the respective species in men's fields was low due to men's prioritisation of other crops (*D. microcarpum*, *H. sabdariffa*, *M. oleifera, T. indica, V. radiata).* The general ownership structures were men-based and determined through the owner of the land on which the species grew. Inheritance of land was restricted to men while women had to get an allowance of their husband to cultivate on men's land. Work division regarding the species' production and acquisition varied but men were more responsible for staple and cash crop production, whereas women oversaw vegetables and pulses. Cash and staple crops' production negatively influenced the production of some of the investigated species because wild growing trees were for instance felled against the will of women (*D. microcarpum, T. indica*). Women sometimes also lacked time for *V. radiata*'s work-intensive harvest because the work on the cash and staple crops fields were prioritised. The harvest of *V. radiata* furthermore risked getting lost as animal feed through the release-ment of livestock to graze around freely latest in the middle of November. For the remaining species, harvest tasks were either mainly shared (*A. digitata*, *B. sapida*, *T. indica*) or without any specific distribution (*B. aegyptiaca*, *D. microcarpum*).

Transfers

Non-monetary transfers represented a further source of acquisition (with exception for *V. radiata*, for which no information was available). Free transfers of plant parts between residents of the same village were reported for several species (*A. digitata*'s leaves, *B. aegyptiaca*, *C. gynandra*, *D. microcarpum*, *O. gratissimum*). Although free transfers were possible for *C. gynandra*, fear for contamination by waste or defecation limited the transfer of its leaves as the species often grew at humid locations within the villages' perimeters. In other cases, there was an informal rule to protect *C. gynandra*'s growing areas from contamination. Other plant parts' free acquisition by transfers depended on the context (*A. digitata*, *B. sapida*, *H. sabdariffa*'s seeds, *M. oleifera*, *T. indica*). Fruits of *A. digitata* which were fallen on the floor could be harvested by everyone, whereas in other cases, the owner of the tree could deny access. For *B. sapida*, free transfers occurred in some cases whereas in others, the high commercial value of the arils increased their sale with negative effects on their free share. The application of so-called gris-gris (voodoo amulets) on fruit trees were a visible sign for the community members' that no free access for harvesting was allowed. *T. indica* was perceived as medicinal species and thus no voodoo amulets were put on the trees in contrast to many other fruit trees. Although in some villages, trees of *T. indica* were considered as common properties, in others, the individual sale of fruits for income provision was paramount.

Taboos

Taboos related to consumption were stated for two species (*A. digitata*, *B. aegyptiaca*). A part of respondents mentioned a taboo for the reproduction of *A. digitata*'s trees. This taboo was reported to exist in the milieu of the ethnic groups Berba and Waama. Some respondents believed that the person who planted a tree of *A. digitata* and consumed its fruits or leaves, would die. The reproduction of *A. digitata*'s trees was perceived to be reserved to God, although people could maintain existing seedlings. Furthermore, harvest on specific fetish trees

of *A. digitata* was completely forbidden. Another barrier for consumption was an individual eating taboo regarding *B. aegyptiaca*'s fruits. One participant of a focus group mentioned that the pulps were forbidden for consumption in his household, although he had no explanation for this rule. For the remaining species, the absence of taboos was without or with a stimulating effect on consumption.

5.4.4.2. Social markers

A further influence represented social markers in terms of social values assigned to the consumption of the plant parts. For six plant parts, positive social markers contributed to their consumption (*A. digitata's leaves*, *B. sapida*, *C. gynandra*, *H. sabdariffa*, *O. gratissimum*, *T. indica*). High appreciation of these plant parts referred to their importance in dietary habits/as part of the local food culture (*A. digitata's leaves*, *H. sabdariffa*, *O. gratissimum*, *P. biglobosa*'s seeds), the cultural importance of the species itself (*A. digitata*, *B. sapida*, *P. biglobosa*, *T. indica*), or their consumption related to special occasions (*H. sabdariffa*'s calyces, *T. indica*, *P. biglobosa*'s seeds), or no specific reason (*C. gynandra*). Fermented paste of *P. biglobosa* had an indispensable role in daily consumption as well as ingredient for meals at festivities. For instance, *B. sapida*'s arils were once called "food of white person" ("nourriture du blanc") which was an expression for their high appreciation.

Low social markers were linked to the consumption of pulps of *P. biglobosa*, which were considered as famine food and as animal feed. Furthermore, the perception that the pulps made you sick was mentioned. Other plant parts were also mentioned to be famine foods but without negative impact on their consumption (*A. digitata*'s pulps, *D. microcarpum*, *B. aegyptiaca*, *P. biglobosa*'s pulps, *V. radiata*). Opinions related to social markers of consumption were diverged but had partly negative influences on consumption of several plant parts (*B. aegyptiaca*, *D. microcarpum*, *M. oleifera* and *V. radiata*). For *B. aegyptiaca*, *D. microcarpum* and *V. radiata*, negative perceptions were associated with a lack of income possibilities for the fruits which made their harvesting useless. In contrast to *D. microcarpum*'s role in diets, its wood was highly appreciated and used. Attributions such as "mountain species" or "food for children" were mentioned. *M. oleifera* was considered on the one hand as very important for medicinal purposes. On the other hand, its leaves were not accepted in diets like other foods and still considered as a foreign species by a part of the respondents.

5.4.4.3. Biological and ecological knowledge and skills

Biological and ecological knowledge and skills were related to the recognition of the species as well as reproduction and maintenance levels. The non-recognition of a species by an interview partner constituted an exception. Reproduction levels had for most species both positive and negative effects on consumption. Several maintenance practices such as weeding, protection from pests and diseases, watering influenced the plant parts consumption. In general, level of maintenance depended on several factors such as physical distances to overcome or the importance of a species in dietary habits.

Recognition

Respondents recognised the following species without exception (*A. digitata*, *B. sapida*, *H. sabdariffa*, *P. biglobosa*) which led not automatically to a positive effect on consumption, as for instance *B. sapida* was recognised but not consumed by everyone. Lack of recognition occasionally occurred for the remaining species (*B. aegyptiaca*, *C. gynandra*, *D. microcarpum*, *M. oleifera*, *O. gratissimum*, *T. indica*, *V. radiata*) and for instance prevented consumption of fruits of *B. aegyptiaca* in some localities or led to cutting of accessible trees. Also, *M. oleifera* was not recognised by some people, although the plant might exist in their surroundings and they might have already heard speaking about it.

Reproduction

For none of the investigated species, the level of reproduction knowledge and skills was solely an enhancing factor. Reproduction by sowing completely lacked for the wild growing species (*B. aegyptiaca*, *D. microcarpum*, *T. indica*) and was done to a limited extent for the remaining eight species. Lack or limited reproduction of perennial species was explained by a lack of knowledge about their reproduction modes and the misbelief that these species only reproduced naturally (*A. digitata*, *B. aegyptiaca*, *D. microcarpum*, *P. biglobosa*, *T. indica*), by unsuccessful reproduction efforts (*P. biglobosa*, *T. indica*), by a lack of interest or incentives (*D. microcarpum*, *O. gratissimum*, *P. biglobosa*, *V. radiata*) and by the lack of genetic material (*H. sabdariffa*, *M. oleifera*, *V. radiata*). Some species' seeds were purposively thrown away in the fields after the consumption of their pulps (*B. aegyptiaca*, *B. sapida*, *P. biglobosa*) or after the harvest of their leaves to enhance their natural reproduction (*C. gynandra*, *O. gratissimum*). Furthermore, naturally reproduced seedlings were sometimes transplanted (*B. aegyptiaca*, *T. indica*) and young seedlings maintained (*A. digitata*, *B. sapida*, *P. biglobosa*, *T. indica*). However, young seedlings of *P. biglobosa* could for instance be mistaken for a weed and accidentally be removed. *M. oleifera*'s reproduction was perceived as easy (twigs could be directly put in earth) for people who were familiar with the species, whereas people who had recently integrated the leaves into their dietary habits, might lacked detailed knowledge about its biology and ecology.

Maintenance

Weeding around the species' surroundings enhanced their production while reducing the risk of being destroyed by fire (*A. digitata*, *B. aegyptiaca*, *B. sapida*, *H. sabdariffa M. oleifera*, *O. gratissimum*, *P. biglobosa*, *T. indica*, *V. radiata*). Two species presented an exception, as *C. gynandra*'s plots were only weeded at the beginning of cultivation without influence on consumption, whereas the missing maintenance of *D. microcarpum* combined with high destruction levels was solely perceived as a barrier for consumption. Watering was further decisive for some plant parts' consumption (*A. digitata*, *C. gynandra*, *H. sabdariffa*, *M. oleifera*, *O. gratissimum*). Regular watering of seedlings of *A. digitata* for instance made them grow faster and enhanced the leaves' accessibility. *O. gratissimum* mainly grew at humid locations, whereby at drier locations women watered the plants with used water from the kitchen. The lack of water restricted harvesting of *M. oleifera*'s leaves to the rainy season and prevented *C. gynandra*'s and *H. sabdariffa*'s production during the dry season. Furthermore, protection from animals and pests was explicitly influencing the consumption of three species (*B. sapida*, *M. oleifera*, *O. gratissimum*). *O. gratissimum* was for instance often planted in courtyards of houses and protected by thorns from destruction by grazing animals, whereas lacking knowledge how to fight against attacks by caterpillars reduced *M. oleifera*'s leaves' consumption.

5.4.4.4. Food and nutrition knowledge and skills

Food and nutrition knowledge and skills included familiarity, processing, storage, and preparation skills as well as health and nutrition awareness. Exposure to food and social learning through transmission of knowledge and skills influenced the general familiarity, processing, storage, and preparation skills as well as the awareness of health and nutrition effects of the plant parts' consumption. Familiarity respectively its absence had mostly uniform influences on consumption. The influence of processing, storage and preparation knowledge and skills as well as awareness of health and nutrition effects depended on these factors' characteristics.

Familiarity

The important role in dietary habits of three species' plant parts was uncontested (*A. digitata*, *H. sabdariffa*, *P. biglobosa*'s seeds). Juices of *H. sabdariffa*'s calyces were for instance often sold during school breaks which made people familiar to them from a young age on. In contrast, lack of consumption of a food since childhood represented a barrier in case of *D. microcarpum*'s fruits because children often lacked knowledge about the pulps' edibility. One

explanation was that many children went to school nowadays and accompanied their parents less into the bushland. For the remaining seven species, the level of familiarity had varied effects on consumption. Some respondents mentioned for instance *B. aegyptiaca*'s fruits as part of their dietary habits since their childhood, whereas others consumed them only in later age stages or were not at all familiar to them. For *B. sapida*, the high familiarity was perceived to be more decisive for consumption than the awareness of the arils' health and nutrition benefits. But the younger generation was less used to consume the arils. *O. gratissimum*'s leaves edibility was not known by everyone, while others consumed them frequently. For *P. biglobosa*'s pulps, statements ranged from no to high familiarity to the pulps' consumption. In any case, their contemporary consumption level remained low.

Processing, storage, and preparation

Processing, storage and preparation techniques had positive effects on consumption of six plant parts (*A. digitata* leaves and pulps, *H. sabdariffa*'s seeds, *M. oleifera*, *P. biglobosa*' seeds, *V. radiata*). Leaves of *A. digitata* and *M. oleifera* were dried and crushed into powder which allowed for consumption during the whole year. However, some issues for keeping hygienic standards and preserving the nutritive values of their leaves remained. Clean drying places for instance often remained insufficient, yellow leaves were often not removed and drying often took place in the sun. Not all respondents were for instance aware of the negative effects of sun drying. Knowledge and skills for transforming *H. sabdariffa*'s and *P. biglobosa*'s seeds into fermented paste was positively influencing their consumption. Also, the various known preparation techniques of seeds of *V. radiata* which were like other legumes such as *V. subterranea* (bambara groundnut) or *V. uniguculata* (cowpea) increased their consumption.

Lack of storage and processing techniques or the willingness to find them decreased consumption of five plant parts (*B. aegyptiaca*, *C. gynandra*, *D. microcarpum*, *O. gratissimum*, *P. biglobosa*'s pulps). Fruits of *B. aegyptiaca*, *D. microcarpum* and leaves of *O. gratissimum* were not of interest for storage, which was partly also the case for *C. gynandra*'s leaves and *P. biglobosa*'s pulps due to their minor role in people's diets. Storage techniques furthermore often remained unsuccessful. Leaves of *C. gynandra* which were harvested during the rainy season for instance often started folding and smelling and also *P. biglobosa*'s pulps started rotting after some time.

Processing, storage and preparation knowledge and skills highly varied for the remaining plant parts (*B. sapida*, *H. sabdariffa*'s leaves and calyces, *T. indica*). Storage techniques of *B. sapida*'s arils extended their consumption period from up to three months to the whole year, whereas in other cases, lack of efficient storage techniques and hygienic conditions caused high loss rates. For *H. sabdariffa*, storage of the calyces enabled their consumption as a vegetable during the whole year. But the lack of processing skills and additives such as sugar partly prevented their transformation to juices but increased the sale's level of the unprocessed calyces.

Health and nutrition awareness

Awareness of nutrition and health benefits of consumption of plants part showed clearly positive effects on four plant parts (*M. oleifera*, *O. gratissimum*, *P. biglobosa*'s seeds, *T. indica*). They were, amongst others, particularly consumed for their positive effects on health. For *M. oleifera*'s leaves, health benefits and not familiarity or sensory preferences (e.g. its leaves were less preferred than ocra) were decisive for their consumption. Fresh or dried leaves were consumed to treat various diseases and concerns (e.g. malaria, tuberculosis, aids, stomach pain, breastfeeding problems, discomfort, malnourishment) *O. gratissimum*'s antibiotic effects were mainly used to treat stomach-related diseases (e.g. intestinal infections, constipation, diarrhoea or ulcers). The leaves constituted of the first sauce which was given to women after giving birth because of their stimulating effect on the milk production. On the other hand, it was reported that compared to the southern part of Benin, nutritional and health knowledge

awareness and consumption were less common. *T. indica*'s pulps' main purpose as beverage was not to provide pleasure but to reduce tiredness during hot weather or to treat several diseases (e.g. malaria, fever, flu, constipation). Also, the fermented paste made from seeds of *P. biglobosa* had several health benefits (e.g. enhanced wellbeing, reduction of tensions).

The lack of health and nutrition awareness with negative consequences on consumption was found for two species (*B. aegyptiaca*, *D. microcarpum*). Both pulps were often consumed to satisfy hunger when being on the way in the bushlands or on the fields, but people had no information about the pulps' nutritive values. However, some respondents mentioned their importance for medicinal uses (e.g. treatment of malaria). For the remaining plant parts, the level of health and nutrition awareness and their influence on consumption varied. Statements about *A. digitata*'s pulps for instance varied from high awareness regarding their nutritive values and usefulness for treatments of diseases to low levels of knowledge limited to the edibility of the pulps and their hunger-killing or appetite-stimulating effects. For *B. sapida*, health and nutritional benefits of the arils (e.g. stimulating the recovery after diseases and the memory, providing proteins) were mentioned, but especially by younger generations, the awareness of health and nutrition benefits and the consumption level were perceived as low. Also, information about specific nutritive values of *H. sabdariffa*'s plant parts were low, although a general awareness about their positive health effects (e.g. reduction of tiredness, prevention from malaria, anaemia (calyces of red variety), reduction of tensions or infections (seeds)) enhanced consumption. For *P. biglobosa*, the misbelief that consuming the pulps caused sickness such as stomach pain or diarrhoea and lacking knowledge about their nutritional benefits were negatively influencing their consumption.

5.4.4.5. Sensory preferences

Sensory preferences were categorised into four sub-aspects (taste, smell, consistency and visual appear) and had both positive and negative effects on the plant parts' consumption. Respondents emphasized the individual characteristics on which sensory preferences depend on.

Taste

High taste preferences with positive effects on consumption included the plant parts' sugary (*B. aegyptiaca*'s *pulps, D. microcarpum*'s pulps, *P. biglobosa*'s pulps) or acid taste (*A. digitata*'s leaves and pulps, *T. indica*'s pulps). Furthermore, unspecified positive taste perceptions were mentioned for the remaining species. Negative taste perceptions included too sugary (*P. biglobosa*'s pulps), too acid (*A. digitata*'s *pulps, T. indica*'s pulps), bitter (*A. digitata*'s older leaves, *M. oleifera*), sour or bitter (*B. aegyptiaca*, *D. microcarpum*) taste. The awareness of health and nutrition benefits sometimes outweighed negatively perceived taste properties (*M. oleifera*, *T. indica*, *V. radiata*). *M. oleifera*'s leaves were for instance less preferred than the sauce made from the leaves of ocra, but the awareness of the leaves' health benefits made their bitter taste more tolerable. Furthermore, some plant parts were also replaced by more preferred fruits (*B. aegyptiaca*, *B. sapida*, *D. microcarpum*) or legumes (*V. radiata*).

Smell

Smell was decisive for the sensory preferences of two plant parts (*O. gratissimum*, *H. sabdariffa*'s seeds). The strong smell of *O. gratissimum*'s leaves could reduce an undesired odour of other food. However, for new consumers of the leaves, the strong smell represented a barrier for consumption. Also, the long-lasting smell after consumption of *H. sabdariffa*'s seeds was disliked by the more urbanised population or people coming back from abroad.

Consistency

Several plant parts were further influenced by the preferences for their consistency (*A. digitata*'s leaves, *B. sapida*, *H. sabdariffa*'s calyces, *M. oleifera*, *V. radiata*). Positive influences included the plant parts' role to replace the fermented paste made from *P. biglobosa*'s seeds

or other protein-rich ingredients such animal-based products (*B. sapida*, *H. sabdariffa*'s calyces). Other plant parts were replaced by other vegetables such as dried ocra during the dry season because the gluey consistency was the main preference criteria for any sauce (*A. digitata*'s leaves, *M. oleifera*) or their consistence was dry and hard (*B. sapida*, *V. radiata*). Furthermore, with *V. radiata*'s old variety, there were often hard seeds remaining after cooking.

Visual appear

The visual appear was an enhancing factor for two plant parts' consumption (*B. sapida*, *H. sabdariffa*'s calyces). The arils of *B. sapida* and the red colour of juices made from *H. sabdariffa*'s calyces were perceived as pleasant. As the red colour of *H. sabdariffa*'s juices was such an important trademark, the juices made from artificial aromas were equally preferred as long they had the same colour.

5.4.4.6. Physiological needs

Physiological needs were related to the fulfilment of hunger and thirst as well as to the state of health respectively pathology. Positive effect of their thirst-stilling effects in contrast to plain water was perceived for two plant parts (*H. sabdariffa*'s calyces, *T. indica*). On the other hand, they were not consumed when suffering from certain diseases such as ulcers. Reduced consumption of other plant parts was caused by their low satisfaction of hunger (*D. microcarpum*), whereas the appetising effect of *A. digitata*'s pulps supported or hindered consumption depending on the individual physiological status.

6. Discussion

6.1. Methodological limitations and potential biases

In the methodological field, there are several limitations regarding the study's cross-lingual and -cultural approach, the sampling and data collection, and analysis. Their characteristics and potential biases on the results are discussed in the following subchapters.

6.1.1. Cross-lingual and -cultural approach

Particular challenges exist in cross-lingual and -cultural qualitative research in which lingual and sociocultural barriers exists between the researchers and the participants of a study (Squires 2009; Liamputtong 2008). The interviews with local experts and focus group participants were conducted in local languages without any real-time interpretation to French. This enabled a natural flow of discussion without interruptions but prevented direct interactions between the interview participants and me and thus direct control of the interview contents. Since the meaning-based transcriptions were only available for me in some delay, gaps in information could only be identified in retrospect. The enumerator's familiarity with the spoken languages, the sociocultural contexts as well as with the biogeographical environment of the research sample was critical to develop a mutual understanding of the research topics. But my time spent with the local communities, particularly in the six research villages, was limited. Indeed, the high familiarity of the enumerators and my passive role as an observer from a different sociocultural and lingual background made the obtention of in-depth information and subtle meanings challenging. For the enumerators were many statements of their interview partners self-evident, and they did not automatically feel the urge to obtain further contextual information. Subtle meanings possibly got further lost in the process of translation and transcription.

6.1.2. Sampling and data collection

A major challenge of this study was to present the influences of the personal food environment on the consumption of the investigated plant parts of the eleven NUS as comprehensively as possible. Saturation of data collection is usually reached when all relevant stakeholders for the study target groups are considered and no further critical information is gained (Krueger and Casey 2014). In this respect, there were four major limitations. They concerned the high diversity of the local population, the wealth of information collected for the eleven species, the considered period as well as the coverage of the interactions and hierarchies of influences.

Concerning the first point, the research sample did not cover the overall diversity of the local population inter alia to gender relations, age groups, socio-linguistic groups, religious affiliations, socio-economic realities, or urbanisation degrees. In addition, a more balanced gender distribution in semi-structured interviews as well as a higher arithmetic mean in age of professional experts would have been beneficial. Approximately two-third of interview partners in semi-structured interviews were men and professional experts had a lower arithmetic mean in age than local experts (arithmetic mean of 34 years vs. 59 years). The perceived influences of the dimensions on the food environment can vary among these sociodemographic characteristics. Several studies indicate that knowledge about plant species is unevenly distributed among gender (Lowore 2001; Gaoue and Ticktin 2009; Buchmann et al. 2010), age (Lokonon et al. 2018; Souto and Ticktin 2012), ethnic groups (Caluwe et al. 2009; Fandohan et al. 2010), and geographic locations (Achigan–Dako et al. 2010). But also among people of the same ethnic groups or villages, knowledge on traditional plant species is not automatically the same (Achigan–Dako et al. 2010). The relationships of these factors and their influences can be complex and thus, a different composition of the research sample's sociodemographic characteristics would possibly have led to different results.

Concerning the second point, several compromises had to be made regarding the level of information of each NUS based on the priori defined data collection period, the high number of investigated NUS and the underlying comprehensive conceptual framework. The predefined data collection period of 30 days put time-pressure on the data collection process and minimised the flexibility to react to the wealth of information obtained. There was no two-step structure between the semi-structured interviews and focus group discussions as initially planned, but a parallel conduction of the different interview types. This reduced a targeted integration of specific information from the semi-structured interviews into the group discussions. Moreover, regarding the first research question, the information regarding the changes in consumption varied among the plant parts between seven (for *H. sabdariffa*'s calyces and seeds) to 27 statements (for *M. oleifera*) in semi-structured interviews (arithmetic mean 16). Furthermore, edible plant parts, mentioned to be consumed by few interview partners in addition to the 16 investigated ones, were excluded from the investigation. This minimised a comprehensive information base of the historical and contemporary consumption of all edible plant parts of the investigated NUS.

The third point deals with the imprecisely indicated temporal frame for changes in consumption by the elaborated interview guidelines, possibly leading to different perception of the changes in consumption and related drivers. From the perspective of the local and professional experts, more plant parts were classified within the main declining and varying trends than for participants of the focus group discussions. For focus group participants, most plant parts showed an upward trend (with exception of the decreasing trend of pulps of *B. aegyptiaca, D. microcarpum, P biglobosa* and *T. indica*). One explanation consists of that focus group participants took mostly a short-term perspective of several years, whereas the main reference point for local and professional experts was their youth. The influence of the considered time frame can be illustrated by plant parts for which different consumption phases came up (e.g. seeds *V. radiata* which decreased over the last decades but increased in consumption in recent years). Furthermore, the collected qualitative data gave relative information on the changes in consumption and current consumption levels, but no precise indications of the extent of change and current consumption frequencies. Direct comparisons among the contemporary consumption frequencies of NUS were only possible through the data from the ranking, which did not distinguish between different plant parts of the same species.

Fourth, interviewing individuals at one point in time to capture changes in their food environment comes with several limitations (Hunter-Adams 2017). Underlying drivers and their interlinkages were not captured in their totality. Moreover, the influences could not be prioritised as the initially planned participatory rating in focus groups was not implemented. Furthermore, some factors were harder to grasp, as people might not be fully aware of them (e.g. some aspects of desirability) or might consist of more delicate topics (e.g. physiological needs in terms of hunger) (Hunter-Adams and Rother 2016). The visual stimuli in form of photographs used during data collection might subconsciously enhanced the focus on physically perceivable objects. With more abstract stimuli, people would have focused more on objects' underlying attributes, such as shared cultural beliefs (Borgatti 1999). Furthermore, most sampled interview partners were part of the rural population of six selected villages in Natitingou, Toucountouna and Tanguiéta in which the GIZ team was active prior to this research project. This fact enabled the research team to quickly build a basis of trust with the interview partners but possibly reinforced the social desirability bias. A part of the research sample might already be affected from other activities of the GIZ and might have answered questions in favour of their assumed expectations. Nevertheless, the collected empirical data comprised of a comprehensive historical and contemporary perspective on the multi-dimensional drivers of the personal food environment and resulted in the most precise data available.

6.1.3. Data analysis

The analysed data depicted the complexity and the multiple realities of personal food environments and consumption patterns but lacked mostly of frequencies of statements since statements of the translated and transcribed focus group discussions were not attributable to individual persons. For research question 1, this limitation was circumvented by counting only the number of different statements made per focus group. Another weighting of the statements of local and professional experts and focus group participants or another setting of intervals between the three main trends in consumption could have derived different trends. This would have been particularly the case for the plant parts with many different statements regarding their changed consumption. For research question 2a, the dimensions and aspects were classified in contributing, counteracting and neutral influences among the plant parts with the same main trend in consumption. They gave an overview on the influence of the different dimensions and aspects but lacked precise data on the frequency of stated influences. For research question 2b, based on the given information, it was not possible to hierarchise the strength of the barriers and enhancing factors in reducing or increasing the consumption of the investigated plant parts. In general, the complementary conducted semi-structured interviews and focus group discussion enabled some degree of data source triangulation, but there was no consistency checking coding by other coders and no stakeholders checks of the results by research participants (Carter et al. 2014).

6.2. Trends, drivers, and contemporary barriers and enhancing factors

The trends in consumption, their underlying drivers, and contemporary barriers and enhancing factors which resulted for the selected NUS are discussed in the following subchapters.

6.2.1. Trends in consumption

The term NUS often refers to species which became underutilised or neglected from a historical perspective (Padulosi and Hoeschle-Zeledon 2004; Chivenge et al. 2015; Azam-Ali 2010). Regarding the investigated period, the results showed that not all species became less consumed by the research sample, but their contemporary consumption levels were mostly low or highly varying (with exception of high consumption levels of *A. digitata*'s leaves, *P. biglobosa*'s seeds). Consumption was not declining among all plant parts, but showed upward, downward, and varying trends.

The consumption trends and contemporary levels showed a high divergence among the investigated plant parts. Noticeable is that the pulps of *B. aegyptiaca* and *D. microcarpum* showed the clearest decrease and the lowest consumption and preference levels among the investigated NUS at the current time. For *D. microcarpum*, other studies confirm the low level and importance of the species' fruit pulps in diets (Agbo et al. 2017; Guin and Lemessa 2000). At the other end of the scale were *M. oleifera* and *C. gynandra* with the clearest positive trends in consumption, but also highly varying current consumption levels. Other studies in Benin confirm that the leaves of *C. gynandra* are consumed from a low to a high level (Dansi et al. 2012; Dansi et al. 2008) and indicate that the leaves of *M. oleifera* are only occasionally consumed in the Sudanian zone of Benin (Achigan–Dako et al. 2010) or labelled as underutilised among four of the five ethnic groups addressed (according to the ethnic groups Fon, Goun, Mahi and Nagot in contrast to Bariba in southern Benin) (Lokonon et al. 2018). The local naming of *M. oleifera* in rural communities in southern Benin can be interpreted that its use for food and medicinal purposes are relatively recent, because it relates solely to the ancient use of the species for the demarcation of fields and houses (Agoyi et al. 2014). For the plant parts which showed a varying trend in consumption, other studies indicate different consumption levels. For instance, *B. sapida* is utilized for centuries and is still an important and frequently consumed food (Ekué et al. 2010; Ekué et al. 2004), whereas other studies indicate low to high

consumption levels (Achigan-Dako et al. 2011; Dansi et al. 2012). *O. gratissimum*'s leaves also vary from non-regular consumption in any of the three zones of Benin (Achigan–Dako et al. 2010), to a high consumption level (Dansi et al. 2008).

In addition, the trends in consumption and contemporary consumption levels were not uniform among the plant parts of the same species. Different trends were found for several plant parts of the same species (*A. digitata*, *H. sabdariffa*, *P. biglobosa)*. Overall, *A. digitata* and *P. biglobosa* were the two currently most preferred and frequently consumed species. Other studies confirm the common use of *A. digitata* in West Africa or in Northern Benin (Shackleton et al. 2009; Codjia et al. 2003). But consumption still varies among different contexts, as for instance the kernels are not consumed in sauces by the ethnic group Dendi (Caluwe et al. 2009). Whereas *P. biglobosa*'s seeds had varying consumption changes over time with a currently high consumption level, the pulps' consumption decreased to a low level. Another study also indicates that the seeds are overexploited in some contexts in Northern Benin (Lokonon et al. 2018), whereas other findings for the pulps are contrasting. More than two decades ago, *P. biglobosa*'s pulps are consumed during periods of food shortage, but their proportion on total effort intake is negligible (van Liere et al. 1995). In another study the pulps are besides the seeds largely consumed by the rural and urban populations, and their sale generates substantial income for many women (Muhammad and Amusa 2003).

Overall, the plant parts assigned to these trends indicated some tendencies, such as mostly increases in consumption for cultivated, annual species (with exception of *M. oleifera*), whereas declines affected fruits pulps of at least partly non-cultivated perennial species. However, the fruit pulps may not the only plant parts with a downward trend of these species. Other edible plant parts of these perennial species such as leaves (besides *A. digitata*'s and *M. oleifera*'s leaves) were excluded from further investigations as their consumption was only mentioned occasionally and would have exceeded a reasonable number of investigating plant parts. Another study mentions for instance a low consumption level of *P. biglobosa*'s leaves in Benin (Achigan–Dako et al. 2010). Fruit pulps generally simply make up the most numerous consumed plant parts of edible perennial species compared to leafy vegetables, seeds, roots, tubers, saps and flowers over Benin (Codjia et al. 2003). The varying trend in consumption in turn affected different plant parts of both perennial and annual species. Looking at the sources of acquisition in the natural environment, decreased trends in consumption occurred for all three non-cultivated species (*B. aegyptiaca*, *D. microcarpum*, *T. indica*). Several studies indicate a general decline in wild fruit and vegetable harvesting in the Sub-Saharan African context (Modi et al. 2006; Bharucha and Pretty 2010; Bvenura and Afolayan 2014). However, already in a study conducted approximately three decades ago in Northern Benin, acquisition of food through wild harvest is the least important source of acquisition in terms of energy and protein intake compared to cultivated, purchased and transferred foods (van Liere et al. 1995). Some more recent findings reveal that a relatively small proportion of the locally available wild plants known by the local community members are consumed (Boedecker et al. 2014), while others highlight the high number of traditional leafy vegetables which are gathered wild and their importance in nutrition of Beninese households (Dansi et al. 2008; Achigan-Dako et al. 2011). As indicated in this study, consumption of the investigated NUS through wild collection might play a subordinate role compared to acquisition through cultivation. Regarding the importance of market-based acquisition, there was no substantial shift from acquisition from the natural (wild collection and cultivation) to the built food environment (market-based transfers) of these plant parts, while free transfers lost importance.

6.2.2. Drivers for consumption and contemporary barriers and enhancing factors

Aspects of all four dimensions of the food environment were underlying the changes in consumption of the investigated NUS. Many of these drivers were already identified by other studies such as land-use changes, changes in purchasing power and orientations to markets, changes in food industry and marketing or knowledge and preferences shifts (Kearney 2010;

Johns and Eyzaguirre 2006; Kuhnlein and Receveur 1996; Pawera et al. 2020). Several studies indicate that sociocultural reasons are mainly causing declines in consumption (Thakur et al. 2017; Bharucha and Pretty 2010), whereas also accessibility or so-called environmental reasons are identified as main drivers (Pawera et al. 2020). From this thesis results', multidimensional changes in accessibility, affordability, convenience and desirability caused the changes in consumption.

6.2.2.1. Accessibility

Accessibility was a key determinant for the decreased consumption of the plant parts with the downward trend, while having positive and negative influences on the other two trends. Several causes for the decreased accessibility of the investigated plant parts were similar to other studies' findings such as decreased accessibility of *A. digitata* in Benin because of limited regeneration due to biotic and abiotic disturbances (Assogbadjo et al. 2008), of *C. gynandra* which is threatened in the Sudanian zone of Benin (Achigan–Dako et al. 2010), partly due to housing developments (Ahouansinkpo et al. 2016) or of *D. microcarpum* due to the high human-induced pressure due to excessive felling (Agbo et al. 2017). At presence, physical accessibility was particularly for *B. aegyptiaca* and *D. microcarpum* perceived as barrier for consumption. Especially *D. microcarpum* is threatened by extinction (Relique et al. 2018) and the use of its wood dominates the consumption of the fruits (Agbo et al. 2017). A limited temporal accessibility was particularly for *B. aegyptiaca*'s, *C. gynandra*'s, *P. biglobosa*'s pulps and *V. radiata*'s consumption an impeding factor. In contrast to the findings of this thesis, *C. gynandra* remains also available during the dry season in home gardens in a study in southern Benin (Ahouansinkpo et al. 2016) where the climate is humid tropical (Achigan-Dako et al. 2011).

Other plant parts' high temporal accessibility are confirmed by other studies, such as *H. sabdariffa*'s leaves which are a key vegetable all over the year in the Sudanian zone of Benin (Achigan–Dako et al. 2010).

6.2.2.2. Affordability

Furthermore several studies indicate that socioeconomic reasons contribute to the decline of NUS (Hunter et al. 2019; Johns and Eyzaguirre 2006; Padulosi et al. 2002; Mayes et al. 2009; Bharucha and Pretty 2010). One often mentioned aspect concerns the limitations in income generation and market demand of NUS (Padulosi et al. 2002; Mayes et al. 2009), but also widened access to markets can reduce their consumption (Bharucha and Pretty 2010). Only for *V. radiata*, poorly developed markets and lack of possibilities for value-adding activities was a barrier. Most plant parts had lower consumption levels at present because they were increasingly sold in detriment of consumption by the research sample (*A. digitata*'s pulps, *B. sapida*, *H. sabdariffa*'s calyces, *P. biglobosa*'s seeds, *T. indica*). Other studies confirm the high sale's level of several species such as *A. digitata*'s plant parts (Chadare et al. 2008; Caluwe et al. 2009), *B. sapida* (Ekué et al. 2004; Dossou et al. 2004) or *P. biglobosa*'s seeds (Lokonon et al. 2018). Interestingly in contrast to the pulps, the leaves of *A. digitata* experienced no negative effects through their marketing, although other studies reveal that the leaves are among the ten most traded traditional vegetables in the Sudanian zone of Benin as well as countrywide (Achigan–Dako et al. 2010) and are also exported to other West African countries (Codjia et al. 2003). More insights into decision-making processes of households for instance regarding the proportion of sold and consumed own-produced food are needed (Fuster et al. 2013).

6.2.2.3. Convenience

Contributing the low accessibility of some plant parts were convenience-related aspects in terms of high time- and other inputs-requiring acquisition, processing, storage, and preparation. Inconvenient acquisition concerned only species which were all at least partly acquired through wild harvesting (with exception of *V. radiata*). Other studies suggest linkages between the decline in wild food consumption and the level of convenience. Wild food consumption is

associated with high efforts (Thakur et al. 2017) and high time consumption (Reyes-García et al. 2015). But wild edible plants are often acquired in opportunistic ways (Ojelel et al. 2019). Such opportunistic behaviours in acquisition and consumption of wild plant parts during other core activities such as hunting, or firewood collection were also described in this thesis' results. According to the optimal foraging theory (Keegan 1986), it is decisive that time and effort invested for consumption do not outweigh with the resultant value from consumption (Ojelel et al. 2019). This might be the case for *B. aegyptiaca* and *D. microcarpum*, which perceived benefits from consumption and general preferences were low. Inconvenient post-acquisition activities were mainly related to limited storage techniques and facilities. Whereas some plant parts were not processed and stored at all (*B. aegyptiaca*, *C. gynandra*, *D. microcarpum*), others suffered particularly from difficult processing and storage (*A. digitata*' pulps, *P. biglobosa*'s pulps) or were substituted by more convenient options (*H. sabdariffa*'s calyces). Such issues are in general confirmed as barriers for consumption by other studies (Mayes et al. 2009; Herforth and Ahmed 2015; Shackleton et al. 2009), but concerned not all investigated NUS. In fact, for *O. gratissimum* or *P. biglobosa*'s seeds, the convenient processing, storage and preparation were solely enhancing their consumption.

6.2.2.4. Desirability

Other studies indicate that specific aspects of desirability contribute to the consumption of the investigated plant species, while others are perceived as barriers. Aspects such as health and nutrition, tradition and culture, food safety or their free access enhance consumption of traditional leafy vegetables or wild edible plants, while the lack of knowledge and skills, negative beliefs and image act as barriers for their consumption (Matenge et al. 2012; Pawera et al. 2020; Bichard et al. 2005). What stands out among the aspects of desirability in this study is that food and nutrition knowledge and skills were uniformly contributing to the upward trend while partly opposing the downward trend. Nevertheless, there were still barriers at present in the level of food and nutrition knowledge and skills among plant parts from all three trends. Only *A. digitata*'s plant parts and *P. biglobosa*'s seeds solely benefitted from high knowledge and skills levels, whereas all other plant parts' consumption was at least partly reduced by the level of familiarity, storage, processing and preparation, or health and nutrition awareness. Other studies for instance confirm the strong link of *M. oleifera*'s consumption to medicinal uses (Gandji et al. 2018; Dansi et al. 2008) or the high health awareness about *O. gratissimum*s' antibiotic properties (Achigan–Dako et al. 2010). For other plant parts, the relationship between the level of health awareness and consumption was more varied in this and other studies' findings. For instance, for *C. gynandra*, the perceived health benefits of the leaves range from stimulation of milk production of breastfeeding women and blood regeneration after deliverance to treatments of infections (Dansi et al. 2008; Ahouansinkpo et al. 2016). But in contrast to the Guinean zone in southern Benin, *C. gynandra* is not among the most often consumed vegetables consumed for medicinal purposes in northern Benin (Achigan–Dako et al. 2010).

Another notion concerns the negative effects of informal institutions on the changed consumption among all investigated plant parts. Thus, besides economic, and physical access, newly established restrictions for free harvesting and shifts from free to market-based transfers reduced the social access to the plant parts' consumption. Remarkably, reduced free transfers among the close social environment affected with exception of *M. oleifera* all plant parts which suffered from negative side-effects of their high sale's level. Besides limitations in free access and transfers, the division of labour had negative impacts on consumption of the mainly cultivated species *H. sabdariffa*, *M. oleifera*, *V. radiata* and the solely wild growing species *T. indica*. One underlying explanation were also here a higher valuation of cash crops by men, which led to a reduced cultivation of the respective NUS and to destruction of large perennial species in agricultural fields. Although women dominate the traditional vegetable value chain from production to marketing in many areas in Sub-Saharan Africa (Dinssa et al. 2016)**,** their empowerment status in Benin is generally low (Alaofè et al. 2017). Another gender-related study in Central Benin indicates that female rice farmers are particularly discriminated

regarding access to land and equipment, resulting in significant negative impacts on their productivity and income (Kinkingninhoun-Mêdagbé et al. 2010). Not only unequal power relations, but also taboos were perceived as a barrier for consumption for two species (*A. digitata*, *B. aegyptiaca*). According to the interview respondents, the regeneration taboo for *A. digitata* had religious and cultural reasons. Other studies confirm the important sociocultural role of *A. digitata* in local belief systems and for cultural identity in Benin (Buchmann et al. 2010; Quiroz and van Andel 2015; Codjia et al. 2003). Furthermore, although only indirectly addressed in this thesis, formal institutions influenced consumption of the investigated plant parts. Other studies confirmed that political reasons contribute to the decline of NUS (Hunter et al. 2019; Johns and Eyzaguirre 2006). In Benin, lack of financial support for research, national promotion strategies are stated barriers for NUS' use (Dansi et al. 2012). In this thesis, amongst others, the politically steered subvention of cash crops such as cotton were, amongst others, underlying the decreased access of some of the species.

Other aspects such as biological knowledge and skills, social markers and sensory preferences for instance were co-responsible for the increase in consumption for the plant parts with the upward trend and the decrease in consumption for the plant parts with the downward trend. Also, some species with the upward trend suffered currently from partly negative images, related to the perception of the species as foreign (*M. oleifera*) or to low marketing possibilities (*V. radiata*). That the reasons for negative social markers can lie deeper shows an investigation in Southwestern Nigeria, where unfavourable attributions towards *M. oleifera* by women are related to constraints in economic resources and access to land (Torimiro et al. 2009). Interestingly, both *M. oleifera* and *V. radiata*, were also negatively affected by the work role division in this thesis' results. In any case, the clearest barrier in social markers concerned *P. biglobosa*'s pulps, which were increasingly perceived as a marker of poverty among the research sample. Other studies confirm that consumption of some plants are increasingly associated with poverty and low esteem among rural communities (Modi et al. 2006), perceived as old-fashioned (Cloete and Idsardi 2013) and less appreciated than exotic ones (Bvenura and Afolayan 2014; Bvenura and Sivakumar 2017; Fentahun and Hager 2009). The contrast to highly appreciated seeds of *P. biglobosa* and the trade-offs between the seeds' and pulps' harvested quality gave deeper insights into the causes of such negative attributions. Besides *P. biglobosa*'s and *A. digitata*'s pulps, all species with a downward trend had also low recognition levels. In contrast to the other solely wild growing species (*B. aegyptiaca*, *T. indica*), *D. microcarpum* particularly suffered from the complete lack of maintenance and was further threatened and destroyed by felling. Nevertheless, partly low recognition levels affected also plant parts of the other two main trends. Low reproduction levels reduced accessibility and consumption of all plant parts, whereas the level of maintenance enhanced most annual species' consumption. For *M. oleifera*, knowledge about the species' biology including its phenology and possibilities for early harvesting of leaves and seeds are directly linked to the consumption level (Torimiro et al. 2009). Another study in Benin reveals gender–related effects regarding consumption of *M. oleifera*'s leaves. Women just need to be aware of the species to use it; while in addition to the awareness, men have to cultivate it before its plant parts were used (Gandji et al. 2018). Furthermore, a decrease in sensory preferences was at least partly a reason for the decline in consumption for most of the plant parts with the decreasing trend (with exception of *T. indica).* Another study about traditional leafy vegetables from the wild suggests that they are less preferred by the younger generation who preferred modern diets (Achigan–Dako et al. 2010). However, already more than two decades, sensory preferences lower for instance the consumption of *B. aegyptiaca*'s pulps (Cook et al. 1998). Whereas another study identifies taste as the most important sociocultural reason for the increase in wild edible plants' consumption (Thakur et al. 2017), positive influences of taste preferences among the plant parts with the increasing trend were only mentioned for *V. radiata*'s seeds. Furthermore, although several plant parts were mentioned to be so-called "famine foods" in this thesis, a study in Southwestern Nigeria suggests that famine foods do not perquisite negative attributions, but they are integrated into everyday diets and normalised (Muller and Almedom 2008).

Most plant parts with a decreasing trend (with exception of *T. indica*) were of particular importance in times of food shortages, as this and other studies results reveal (Assogbadjo et al. 2006; Guin and Lemessa 2000; van Liere et al. 1995). But the physiological needs to consume these plant parts partly decreased over time and thus contributed to their reduced consumption.

6.2.3. Conclusion

Multi-dimensional drivers of the personal food environment determined the changes in consumption and their contemporary levels for each plant part in a unique way. The research sample of this thesis were farmers in rural areas which predominately depended on the natural food environment for acquiring and consuming the investigated NUS. Nevertheless, new foods became more accessible, affordable, convenient, and/or desirable to them. They partly replaced consumption of some of the investigated plant parts by other foods as already indicated by other studies (Kuhnlein and Receveur 1996; Bharucha and Pretty 2010). However, the replacement of individual components such as specific plant parts by new options should not be automatically interpreted as loss of knowledge following the diversity hypothesis (Müller-Schwarze 2006). The integration of exotic plants in traditional diets does not automatically results from cultural erosion or environmental degradation, this suggest also empirical findings in Benin's urban areas (Sodjinou et al. 2009). The processes in which new foods are integrated and information gets lost are long-term adaptative developments (Albuquerque and Hanazaki 2009), whereas the so-called westernisation or other forms of acculturation imply passivity of local populations to external drivers. Culture and knowledge are dynamic over time and the integration of new plants does not necessary imply loss of knowledge about traditional plants (Albuquerque 2006). The results of this thesis showed that many interrelated factors of the sociocultural and bio-geophysical environment shaped consumption of the investigated plant parts.

6.3. Implications for research and promotion

In this final chapter, implications for future research and for the development of promotional strategies, including reflections about the prioritisation of the investigated NUS, are outlined.

6.3.1. Implications for research

The conceptualisation of food environments is not yet complete. Theoretical and methodologies refinements are needed for measuring the different types (natural/built), domains (internal/external) and parameters (dimensions and aspects) of food environments in a more standardized way (Herforth et al. 2017; Turner et al. 2020). The fact that a further elaboration of the concept of food environments is still pending, show for instance the empirical findings of this thesis in which biological properties in terms of physiological needs were a further determinant of food consumption. As not integrated in the concept of food environments yet, food's material functions such as satisfying physiological needs are often underestimated in food studies (Neuman 2019). Furthermore, also with regard to integrate sustainability or links to sustainable diets into existing food environment frameworks needs further efforts (Downs et al. 2020).

Not only from theoretical and methodological points of views are comparisons of food environment studies across temporal and geographical contexts limited (Turner et al. 2020). Regarding the temporal perspective, most studies are looking at the drivers for a decline than for other changes and related influences on consumption (Pawera et al. 2020). Furthermore, fluctuations in consumption over the year as well as long-term changes need to be captured by further longitudinal research about food environments and related influences (Hunter-Adams 2017; Fuster et al. 2013). Region-wise, the number of food environment studies in Sub-Sahara Africa is low with a total of eleven articles (Turner et al. 2020). They investigate a wide range of different topics such as the awareness of food labelling among consumer in Ghana (Ababio et al. 2012), the influence of large commercial food production entities on the food environment

in South Africa (Igumbor et al. 2012), or the personal food environment of cross-border migrant women in South Africa (Hunter-Adams 2017). This thesis contributed to the particularly low number of qualitative studies which considered all dimensions of the personal food environment as well as both the natural and built food environment in shaping acquisition and consumption (Herforth and Ahmed 2015; Turner et al. 2018). Nevertheless, a mixed-method approach which considers both internal and external domains of food environments would not only contribute a more comprehensive analysis, but also reduce the high variations and biases of consumption patterns and related influences (FAO et al. 2019; Turner et al. 2020). A great number of barriers and enhancing factors was identified in this thesis, but with great probability not all were determining consumption to the same extent. Overall, the intensity of influences and their interrelations including trade-offs between the dimensions of the personal food environment were not fully covered. Therefore, more systemic research on the dimensions and interactions of food environments is needed.

6.3.2. Implications for promotion

The understanding of the causes behind the low level of use and neglect of NUS forms the basis to develop strategies to enhance their consumption (Padulosi et al. 2002). Furthermore, the description of the different types of food environments people have access to, including acquisition from the wild, from own cultivation, from market and non-market based transfers provide some entry points for possible interventions (Herforth et al. 2017). In order to increase the consumption of the plant parts studied, different aspects of the four dimensions of food environments are relevant (Table 18).

Table 18 Potential intervention points for promotion of the investigated NUS

Dimension	Potential intervention point	Species	*A. digitata*			*B. aegyptiaca*	*B. sapida*	*C. gynandra*	*D. microcarpum*	*H. sabdariffa*			*M. oleifera*	*O. gratissimum*	*P. biglobosa*		*T. indica*	*V. radiata*
		Plant part	Kernels	Leaves	Pulps	Pulps	Arils	Leaves	Pulps	Calyces	Leaves	Seeds	Leaves	Leaves	Pulps	Seeds	Pulps	Seeds
Accessibility	Protection from abiotic disturbances		x	x	x	x	x		x						x	x	x	
	Protection from biotic disturbances		x	x	x	x	x		x						x	x	x	
	Availability of land for natural and human-induced reproduction		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
	Provision of genetic material								x	x	x	x	x					x
	Water resources for cultivation in the dry season		x	x	x			x					x	x				
	Presence on markets					x		x	x				x					x
Affordability	Affordable prices for market-based acquisition				x	x	x									x		x
	Balance auto-consumption and sale's level				x	x	x									x	x	
	Establishment market demand					x		x	x									x
Convenience	Facilitation of harvest modes		x	x	x	x												x
	Coordination with workload for other crops														x	x		x
	Material for processing and storage				x					x						x		
	Clean water for processing to juices																x	
	Storage faciliities				x		x	x							x		x	x
Desirability	Recognition and knowledge of edibility					x	x	x	x				x	x			x	x
	Incentives and skills for reproduction		x	x	x	x	x	x	x					x			x	x
	Incentives and skills for maintenance		x	x	x	x	x		x				x		x	x	x	
	Protection techniques against pests and diseases						x						x	x				
	Processing and storage techniques in humid conditions							x						x	x			x
	Community relations/social networks for transfer-based acquisition		x	x	x		x			x	x	x	x				x	
	Intra-household relations and work roles									x	x	x	x				x	x
	Dealing with taboos		x	x	x	x												
	Establichment of positive social markers					x			x				x		x		x	
	Awareness for nutrition and health benefits					x	x	x	x	x	x				x			x
	Preparation modes for enhaced sensory prefrences		x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	

Some plant parts have barriers to overcome in all four dimensions of the personal food environment, whereas for others, only their accessibility and desirability are challenging. As the natural food environment was the most important source of acquisition for the selected NUS, particularly the availability of sufficient land for natural reproduction and cultivation of the investigated NUS is needed. Further topics within the dimension of accessibility include the protection from abiotic and biotic disturbances of several plant parts, the provision for genetic material and access to water resources for the species' cultivation. Furthermore, the dimension of affordability shows that the financial assets of the local population reduce the market-based acquisition of some plant parts. Several plant parts also require a more favourable balance between their auto-consumption and sale's level. Regarding convenience, the highest number of plant parts would benefit from facilitated harvesting modes and from improved storage facilities.

In addition to the fact that the plant parts need to be accessible, affordable and convenient, they must also fall within the desirable range of food products for the research sample. Whereas some topics regarding knowledge and skills (e.g. protection techniques against pest and diseases, processing and storage techniques in humid conditions) and informal institutions (e.g. dealing with taboos) concern only three to four plant parts, other intervention points could enhance the desirability of several plant parts. At least half out of the 16 investigated plant parts would benefit from higher recognition, skills and incentives for reproduction and maintenance, awareness about health and nutrition benefits and enhanced preparation modes for higher preferences. However, knowledge-related measures should not be the only point of intervention (Chadwick et al. 2013; Powell et al. 2015; Story et al. 2008). These measures could be complemented through a strengthening of community networks to preserve the practice of non-monetary transfers among neighbours, while acknowledging that social groups such as communities are neither static nor isolated. Individuals and groups are stratified, for example among social status, financial resources and power (Neuman 2019). Thus, particular attention of work roles and intra-household relations with a focus on gender dynamics and family hierarchy (Hunter-Adams and Rother 2016) seem promising.

6.3.3. Prioritisation of the selected NUS for promotion

To develop promotional activities, there exist considerable differences among the plant parts' starting points regarding their consumption trends, current consumption levels and related barriers and enhancing factors. The plant parts with a downward trend could be defined as underutilised regarding the investigated period (*A. digitata*'s pulps, *B. aegyptiaca*, *D. microcarpum*, *P. biglobosa*'s pulps, *T. indica*) and the plant parts with the varying trend furthermore might be located at a tipping point with respect to their future trend in consumption (*A. digitata*'s leaves and kernels, *B. sapida*, *H. sabdariffa*'s kernels, *O. gratissimum*, *P. biglobosa*'s seeds). These plant parts might require more urgent interventions than the ones with an upward trend, so they do not completely disappear from people's food environments and diets. Nevertheless, there are several barriers to increased consumption for all plant parts. Some plant parts had particularly low consumption levels in some geographic parts of the research area (e.g. *B. aegyptiaca* in Natitingou and Toucountouna) which lowered their consumption. Again others had an unexploited potential in economic terms because they were not at all part of market-transfers (*C. gynandra*) or traded to a little extent (e.g. *B. aegyptiaca*, *D. microcarpum*, *V. radiata*), whereas others showed a tendency to overutilisation in economic terms with negative effects on the auto-consumption by the research sample (*A. digitata*'s pulps, *B. sapida*, *H. sabdariffa*'s calyces, *P. biglobosa*'s seeds, *T. indica*) or on other plant parts of the same species (*P. biglobosa*'s pulps). Some could be viewed as underutilised in social terms because they were among the least preferred species (*D. microcarpum, B. aegyptiaca*), whereas others belonged to the most preferred species (*A. digitata*, *P. biglobosa*, *H. sabdariffa*). These differences might provide some starting points to counteract the specific under- and overutilisation. Nevertheless, more criteria for the prioritisation of the species need to be included than covered by this thesis, such as more precise information on economic aspects (e.g. market use,

market value, contribution to household income), nutritional aspects (e.g. nutritional value) and sociocultural aspects (e.g. contribution to women empowerment (Hunter et al. 2019; Dansi et al. 2012).

6.3.4. Conclusion

The research about food environments is still at its beginnings and further theoretical, methodological, and empirical work is needed. For the selected NUS, there is no one-fits-all strategy to enhance their consumption. Multi-dimensional strategies which take plant-part specific differences into account are more likely to overcome their various barriers in consumption. The strategical development of promotion activities for the selected NUS should be conducted in a participatory way with the local communities. Particularly in local food environments where food producers and consumers overlap and smallholders are often involved in all activities along food systems' value chains, conservation of plant species through sustainable use is key (Borelli et al. 2020). In Benin, national research and development programmes for NUS which involve all the possible actors (researchers, developers and producers) are needed (Dansi et al. 2012). "Traditionally, an invisible firewall has separated the agriculture, health, and nutrition sectors" (Pinstrup-Andersen 2012, p. 1). The disconnect and lack of coordination of the various stakeholders involved is one of the main barrier for a better integration of NUS into modern food systems (Hunter et al. 2019). As multiple interlinkages including trade-offs and wins exist, an integrated, multidisciplinary systems approach to research and development system is needed (Ericksen et al. 2012; Pinstrup-Andersen 2012).

7. Conclusion and outlook

This study showed that different trends in consumption occurred for the investigated plant parts of the eleven NUS, ranging from increasing, decreasing to varying trends. Although not all plant parts were in a situation of decreasing consumption, most of the plant parts under study had currently low or highly variable levels of consumption. The drivers related to the changes in consumption as well as the contemporary barriers and enhancing factors included aspects of accessibility, affordability, convenience and desirability. Whiles some of the investigated plant parts were only not accessible and desirable enough in some respects at present, others' consumption was reduced by all four dimensions of the personal food environment. Instead of focusing solely on individual behaviours and on knowledge-related intervention points, a holistic view on the constraining and enabling contexts in which people make food choices should be adopted (Story et al. 2008; Hunter-Adams 2017; Powell et al. 2015; Chadwick et al. 2013).

To create enabling food environments, more research and supportive measures are needed in all four dimensions of the personal food environment. Changing food environments need particular attention and longitudinal, mixed-method approaches could lead to a better understanding of the socio-ecological processes which shape changes in consumption, including their underlying drivers and outcomes (Turner et al. 2020; FAO et al. 2019). Whereas the research sample of this study depended nowadays like in the past predominantly on the natural food environment for the acquisition and consumption of the investigated plant parts, in urban areas of LMIC, the influence of the built food environment and globalisation are assumed to be stronger (Hunter-Adams and Rother 2016; Fuster et al. 2013). Also in Benin, annual urban population growth across the country is around 3.9% (World development indicators database 2019) and alternative food and medicinal sources partly replaced the investigated plant parts because they became more accessible, affordable, convenient and/or desirable. Nevertheless, the integration of new foods does not automatically lead to a loss of traditional foods and associated knowledge (Albuquerque and Hanazaki 2009; Müller-Schwarze 2006) and lower income countries do not automatically following the same social, technological and economic pathways as well as dietary patterns as today's higher income countries (Wade 2003).

Whereas this thesis only investigated a minor part of the research sample's diets and identified specific barriers to consumption of the investigated plant parts, diets should be understood in their totality including the complexity of interacting influences (Fuster et al. 2013) and the embeddedness of food consumption in various other practices of daily life (O'Neill et al. 2019). The promotion of NUS might be particularly challenging in contexts in which fruit and vegetable consumption is on a generally low level like in Benin, where the share of fruit and vegetable consumption on the total energy intake makes up approximately 3% (FAO 2011). One of the principal challenges consists of securing access to sufficient, nutritious, healthy and affordable food that is produced in a sustainable way (Bailey 2016; Willett et al. 2019). The development of strategies based on the identified barriers and enhancing factors to promote the consumption of nutritious and healthy foods should be conducted in a participatory way with the local communities and all other stakeholders involved (Borelli et al. 2020; Hunter et al. 2019; Dansi et al. 2012). Diversity in food systems is an essential component for the resilience of local people to social, cultural, economic, and environmental change (Powell et al., 2015) and if the barriers of NUS can be overcome, these species can exploit more of their potential with various benefits for local people's nutrition and health, livelihoods and the natural resource base.

8. Summary

Although the African continent is considered as the most diverse region in the world in terms of wild and cultivated foods (Plant Resources of Tropical Africa 2010), especially Sub-Saharan Africa remains the world's most food insecure region (FAO et al. 2019). With regard to dietary quality and diversity (Powell et al. 2015), but also to environmental sustainability (Bailey 2016), and social welfare (Padulosi et al. 2015), the potentials of many neglected and underutilised species (NUS) remain unexploited. For the enhanced consumption of NUS, various geographic, agronomic, socioeconomic and sociocultural constraints within food systems need to be overcome (Baldermann et al. 2016; Padulosi and Hoeschle-Zeledon 2004). Particularly in lower income countries, food systems including diets are under transition and little is documented about what drives food choices and consumption of NUS (McMullin et al. 2019; Kuhnlein and Receveur 1996). This master's thesis therefore investigated the influences of the personal food environment on the consumption of NUS in three communes in the department of Atacora in northern Benin (West Africa). The objectives were to identify changes in the consumption of eleven selected NUS and related drivers from a historical perspective, as well understanding contemporary barriers and enhancing factors for consumption. The personal food environment comprises the constraining and enabling contexts which shape people's food consumption, whereby the four dimensions of accessibility, affordability, convenience, and desirability are distinguished (Turner et al. 2018).

The research area in the Atacora department in northern Benin is located in the Sudanian zone, which is characterised by a dry tropical climate with a mean annual rainfall of 900-1100 mm and temperatures ranging from 24-31°C (Achigan-Dako et al. 2011). The main vegetation types in the area are shrub and tree savannas (Akoègninou et al. 2006). The majority of the approximately 770'000 residents of the department of Atacora belong to the rural population and agriculture, craft and trade are the main livelihood activities (Fogny and Trentmann 2016). Following a purposive sampling strategy, members of the local, rural population and professionals working in the fields of agriculture, health and nutrition in three communes of the Atacora department were interviewed. In total, 42 semi-structured interviews with local and professional experts and 12 focus group discussions with the villagers of six villages in the three communes were conducted. Due to language barriers between me and some of the interview partners, semi-structured interviews with local experts and focus group discussions were conducted and recorded by two enumerators in local languages (Waama, Naténi and Ditamari), whereas professional experts were interviewed by me in French. The transcribed text material was analysed by qualitative, structuring content analysis (Bogner et al. 2014; Mayring 2007). In a first step, the text material was coded with Atlas.ti based on a deductively developed coding framework of the dimensions and aspects of the personal food environment. Secondly, the coded text passages were paraphrased, generalised, and reduced and led to derived answers to the research questions.

Among the 16 investigated plant parts of the eleven NUS, three main trends in consumption were identified. Five investigated plant parts of four species showed an increase in consumption (*C. gynandra*'s leaves, *H. sabdariffa*'s calyces and leaves, *M. oleifera*'s leaves, *V. radiata*'s seeds). Five plant parts of five other species decreased in consumption (*A. digitata*'s pulps, *B. aegyptiaca*'s pulps, *D. microcarpum*'s pulps, *P. biglobosa*'s pulps, *T. indica*'s pulps), while six plant parts showed a varying, inconclusive trend (*A. digitata*'s leaves and kernels, *B. sapida*'s arils, *O. gratissimum*'s leaves, *P. biglobosa*'s seeds). All four dimensions of the personal food environment were in a specific interplay co-responsible for the changes in consumption for each plant part. Among the plant parts with the main increasing trend in consumption, various aspects of desirability, above all increased food and nutrition knowledge and skills, led to a positive consumption trend. Also, the dimensions of accessibility and convenience were partly contributing to the increase, whereas the decreased affordability had counteracting or neutral influences. The downward trend in consumption was most uniformly traced back to a decline in accessibility, but several reasons made these plant parts also less affordable and less

desirable. The high variation in the dimensions' influences on the plant parts with the varying trend reflected their non-uniform changes.

While some of the plants parts' contemporary consumption was reduced by their accessibility, affordability, convenience and desirability, other plant parts had no barriers in their level of affordability and convenience (*H. sabdariffa*'s leaves and seeds, *M. oleifera*'s leaves, *O. gratissimum*'s leaves). The low accessibility of most plant parts was related to environmental drivers such as land-use changes, biotic and abiotic disturbances and low or lacking reproduction whose underlying causes consisted of aspects such as a short-term profit thinking (e.g. prioritisation of the species' wood) , unfavourable formal (e.g. subsidies for cash crops) and informal (e.g. taboos for reproduction) institutions and low knowledge and skills levels. In the dimension of affordability, the most common barrier was the high sale's level of mostly perennial species' plant parts. Barriers in convenience were on the one hand associated with the plant parts' harvesting, but also with time-consuming and high inputs requiring processing, storage, and preparation activities. Furthermore, all plant parts had several consumption-reducing aspects in the dimension desirability. For instance, informal institutions about restricting free access and transfers of the plant parts, favouring unequal labour division and defining taboos as well as negative social markers, low levels in knowledge and skills, unfavourable sensory preferences and low physiological needs had negative effects on specific plant parts' consumption.

The consumption trends revealed for the plant parts indicated some tendencies, such as mostly increases in consumption of cultivated, annual species (with exception of *M. oleifera*), whereas the downward trend affected at least partly or solely wild collected fruit pulps of perennial species. Several studies indicate a decline in wild edible plant consumption in the Sub-Saharan African context (Modi et al. 2006; Bharucha and Pretty 2010; Bvenura and Afolayan 2014). But an earlier study shows also that wild collection plays already a subordinate role for the acquisition of *P. biglobosa*'s pulps some decades ago (van Liere et al. 1995). The identified drivers of changing food environments such as land-use changes, changes in purchasing power and orientations to markets, convenience, or knowledge and preferences shifts are in line with other findings (Kearney 2010; Johns and Eyzaguirre 2006; Kuhnlein and Receveur 1996; Pawera et al. 2020). Whereas several studies indicate that sociocultural reasons are mainly causing declines in consumption (Thakur et al. 2017; Bharucha and Pretty 2010), others identify accessibility or so-called environmental reasons as a main cause (Pawera et al. 2020). From this thesis results', both so-called sociocultural and environmental factors were driving the changes and contemporary states in consumption in a unique way for each plant part.

Especially in contexts where the risk and prevalence of both under- and overnutrition is present, nutrition represents a complex and dynamic field (Fuster et al. 2013). More empirical, participatory qualitative or mixed-methods studies should in-depth capture the influences and interactions of the dimensions in food environments in shaping consumption (FAO et al. 2019; Turner et al. 2020), preferably supplemented by longitudinal research (Hunter-Adams 2017; Fuster et al. 2013). Instead of focusing solely on individual behaviours and on knowledge-related intervention points, research and policy interventions should adopt a holistic view on the constraining and enabling contexts in which people consume foods (Padulosi et al. 2002). By making these species more accessible, affordable, convenient and desirable options, used by the local population in a sustainable way, NUS can exploit more of their potential contributing to food and nutrition security, social welfare and environmental security (McMullin et al. 2019; Borelli et al. 2020).

9. References

Ababio, P. F.; Adi, D. D.; Amoah, M. (2012): Evaluating the awareness and importance of food labelling information among consumers in the Kumasi metropolis of Ghana. In *Food Control* 26 (2), pp. 571–574. DOI: 10.1016/j.foodcont.2012.02.015.

Achigan-Dako, E. G.; N'Danikou, S.; Assogba-Komlan, F.; Ambrose-Oji, B.; Ahanchede, A.; Pasquini, M. W. (2011): Diversity, geographical, and consumption patterns of traditional vegetables in sociolinguistic communities in Benin: implications for domestication and utilization. In *Economic Botany* 65 (2).

Achigan–Dako, E. G.; Pasquini, M. W.; Assogba Komlan, F.; N'Danikou, S.; Dansi, A.; Ambrose–Oji, B. (2010): Traditional vegetables in Benin. In *Institut National des Recherches Agricoles du Bénin*.

Adomou, A. C. (2005): Vegetation patterns and environmental gradients in Benin: implications for biogeography and conservation. Wageningen, Univ., Diss. Wageningen.

Agbo, I. R.; Missihoun, A. A. l.; Vihotogbe, R.; Assogbadjo, E. A.; Ahanhanzo, C.; Agbangla, C. (2017): Impacts des usages traditionnels sur la vulnérabilité de Detarium microcarpum Guill. & Perr. (Caesalpiniaceae) dans le district phytogéographique Zou au Bénin (en Afrique de l'Ouest). In *Int. J. Bio. Chem. Sci* 11 (2), p. 730. DOI: 10.4314/ijbcs.v11i2.16.

Agoyi, E. E.; Assogbadjo, A. E.; Gouwakinnou, G.; Okou, F. A.; Sinsin, B. (2014): Ethnobotanical Assessment of Moringa oleifera Lam. in Southern Benin (West Africa). In *Ethnobotany Research and Applications* 12, pp. 551–660.

Ahmed, S.; Byker S. C.; Smith, T.; Shanks, J. (2018): Fruit and vegetable desirability is lower in more rural built food environments of Montana, USA using the Produce Desirability (ProDes) Tool. In *Food security* 10 (1), pp. 169–182. DOI: 10.1007/s12571-017-0748-1.

Ahouansinkpo, E.; Atanasso, J.; Dansi, A.; Adjatin, A.; Azize, Orobiyi; Sanni, A. (2016): Ethnobotany, Phytochemical Screening and Toxicity Risk of Cleome gynandra and Cleome viscosa, two traditional leafy vegetables vonsumed in Benin. In *Int.J.Curr.Microbiol.App.Sci* 5 (2), pp. 813–829. DOI: 10.20546/ijcmas.2016.502.093.

Ajzen, I. (1991): The theory of planned behavior. In *Organizational behavior and human decision processes* 50 (2), pp. 179–211.

Akoègninou, A.; Van der Burg, W. J; van der Maesen, L. J. G. (2006): Flore analytique du Bénin (06.2).

Alaofè, Halimatou; Zhu, Min; Burney, Jennifer; Naylor, Rosamond; Douglas, Taren (2017): Association Between Women's Empowerment and Maternal and Child Nutrition in Kalalé District of Northern Benin. In *Food and nutrition bulletin* 38 (3), pp. 302–318. DOI: 10.1177/0379572117704318.

Albuquerque, U. P. (2006): Re-examining hypotheses concerning the use and knowledge of medicinal plants: a study in the Caatinga vegetation of NE Brazil. In *Journal of ethnobiology and ethnomedicine* 2, p. 30. DOI: 10.1186/1746-4269-2-30.

Albuquerque, U. P.; Cruz da Cunha, L. V. F.; Lucena, R. F. P.; Alves, R. R. N. (Eds.) (2014): Methods and Techniques in Ethnobiology and Ethnoecology. New York, NY: Springer New York (Springer Protocols Handbooks).

Albuquerque, U. P.; Hanazaki, N. (2009): Five Problems in Current Ethnobotanical Research—and Some Suggestions for Strengthening Them. In *Hum Ecol* 37 (5), pp. 653–661. DOI: 10.1007/s10745-009-9259-9.

Alonso, E. B.; Cockx, L.; Swinnen, J. (2018): Culture and food security. LICOS Discussion Paper Series. Discussion Paper 398. In *Global food security* 17, pp. 113–127.

Antenner, A.; Atamari; Yoki (2007/2008): Adansonia Digitata. Edited by Wikipedia. Available online at https://en.wikipedia.org/wiki/Adansonia_digitata, updated on 10/18/2020.

Archer, M. (1998): Culture and Agency: The Place of Culture in Social Theory. In *Cambridge: Cambridge University Press.*

Arimond, M.; Ruel, M. T. (2004): Dietary diversity is associated with child nutritional status: evidence from 11 demographic and health surveys. In *The Journal of Nutrition* 134 (102579-2585).

Assogbadjo, A. E.; Glèlè Kakaï, R.; Vodouhê, F. G.; Djagoun, C.A.M.S.; Codjia, J.T.C.; Sinsin, B. (2012): Biodiversity and socioeconomic factors supporting farmers' choice of wild edible trees in the agroforestry systems of Benin (West Africa). In *Forest Policy and Economics* 14 (1), pp. 41–49. DOI: 10.1016/j.forpol.2011.07.013.

Assogbadjo, A. E.; Kakaï, R. G.; Chadare, F. J.; Thomson, L.; Kyndt, T.; Sinsin, B.; van Damme, P. (2008): Folk classification, perception, and preferences of baobab products in West Africa: consequences for species conservation and improvement. In *Economic Botany* 62 (1), pp. 74–84.

Assogbadjo, A. E.; Kyndt, T.; Sinsin, B.; Gheysen, G.; van Damme, P. (2006): Patterns of genetic and morphometric diversity in baobab (Adansonia digitata) populations across different climatic zones of Benin (West Africa). In *Annals of botany* 97 (5), pp. 819–830. DOI: 10.1093/aob/mcl043.

Aubel, J. (2012): The role and influence of grandmothers on child nutrition: culturally designated advisors and caregivers. In *Maternal & child nutrition* 8 (1), pp. 19–35. DOI: 10.1111/j.1740-8709.2011.00333.x.

Avohou, H. T.; Vodouhe, R. S.; Dansi, A.; Kpeki, B.; Bellon, M. (2012): Ethnobotanical factors influencing the use and management of wild edible plants in agricultural environments in Benin. In *Ethnobotany Research and Applications* 10, pp. 571–592.

Azam-Ali, S. N. (2010): Fitting underutilised crops within research-poor environments: Lessons and approaches. In *South African Journal of Plant and Soil* 27 (4), pp. 293–298. DOI: 10.1080/02571862.2010.10639997.

Bailey, A. (2016): Mainstreaming agrobiodiversity in sustainable food systems: Scientific foundations for an agrobiodiversity index - Summary.

Baldermann, S.; Blagojević, L.; Frede, K.; Klopsch, R.; Neugart, S.; Neumann, A. et al. (2016): Are Neglected Plants the Food for the Future? In *Critical Reviews in Plant Sciences* 35 (2), pp. 106–119. DOI: 10.1080/07352689.2016.1201399.

Bernard, R. H. (2017): Research methods in anthropology. Qualitative and quantitative approaches. Fourth edition. 4th ed.: AltaMira Press.

Bharucha, Z.; Pretty, J. (2010): The roles and values of wild foods in agricultural systems. In *Philosophical transactions of the Royal Society of London. Series B, Biological sciences* 365 (1554), pp. 2913–2926. DOI: 10.1098/rstb.2010.0123.

Bichard, A.; Dury, S.; Schönfeldt, H. C.; Moroka, T.; Motau, F.; Bricas, N. (2005): Access to urban markets for small-scale producers of indigenous cereals: a qualitative study of consumption practices and potential demand among urban consumers in Polokwane. In *Development Southern Africa* 22 (1), pp. 125–141. DOI: 10.1080/03768350500044560.

Boedecker, J.; Termote, C.; Assogbadjo, A. E.; van Damme, P.; Lachat, C. (2014): Dietary contribution of Wild Edible Plants to women's diets in the buffer zone around the Lama forest, Benin – an underutilized potential. In *Food Sec.* 6 (6), pp. 833–849. DOI: 10.1007/s12571-014-0396-7.

Bogner, A.; Littig, B.; Menz, W. (2014): Interviews mit Experten. Wiesbaden: Springer Fachmedien Wiesbaden.

Borelli, T.; Hunter, D.; Padulosi, S.; Amaya, N.; Meldrum, G.; Oliveira Beltrame, D.M. Samarasinghe, G. et al. (2020): Local Solutions for Sustainable Food Systems: The Contribution of Orphan Crops and Wild Edible Species. In *Agronomy* 10 (231), pp. 1–25. DOI: 10.3390/agronomy10020231.

Borgatti, S. P. (1999): Elicitation techniques for cultural domain analysis. In *The ethnographer's toolkit* 3, pp. 115–151.

Brandt, R.; Mathez-Stiefel, S. L.; Lachmuth, S.; Hensen, I.; Rist, S. (2013): Knowledge and valuation of Andean agroforestry species: the role of sex, age, and migration among members of a rural community in Bolivia. In *Journal of ethnobiology and ethnomedicine* 9 (1).

Bricas, N. (1998): Cadre conceptuel et méthodologique pour l'analyse de la consommation alimentaire urbaine en Afrique. In *Série urbanisation, alimentation et filières vivrières* (1).

d. Brinberg; Axelson, M. L. (1990): Increasing the consumption of dietary fiber: A decision theory analysis. In *Health Education Research* 5 (4), pp. 409–420.

Buchmann, Christine; Prehsler, Sarah; Hartl, Anna; Vogl, Christian R. (2010): The importance of baobab (Adansonia digitata L.) in rural West African subsistence--suggestion of a cautionary approach to international market export of baobab fruits. In *Ecology of food and nutrition* 49 (3), pp. 145–172. DOI: 10.1080/03670241003766014.

Bvenura, C.; Afolayan, A. J. (2014): Ethnobotanical survey of wild vegetables in Mbashe and Nkonkobe municipalities, Eastern Cape Province, South Africa. In *Acta Botanica Gallica* 161 (2), pp. 189–199. DOI: 10.1080/12538078.2014.909327.

Bvenura, C.; Sivakumar, D. (2017): The role of wild fruits and vegetables in delivering a balanced and healthy diet. In *Food research international (Ottawa, Ont.)* 99 (Pt 1), pp. 15–30. DOI: 10.1016/j.foodres.2017.06.046.

Caluwe, E. de; Smedt, S. de; Assogbadjo, A. E.; Samson, R.; Sinsin, B.; van Damme, P. (2009): Ethnic differences in use value and use patterns of baobab (Adansonia digitata L.) in northern Benin. In *African Journal of Ecology* 47 (3), 443-440.

Carter, N.; Bryant-Lukosius, D.; DiCenso, A.; Blythe, J.; Neville, A. J. (2014): The use of triangulation in qualitative research. In *Oncology nursing forum* 41 (5), pp. 545–547. DOI: 10.1188/14.ONF.545-547.

Chadare, F. J.; Hounhouigan, J. D.; Linnemann, A. R.; Nout, M. J. R.; van Boekel, M. A. J. S. (2008): Indigenous Knowledge and Processing of Adansonia Digitata L. Food Products in Benin. In *Ecology of food and nutrition* 47 (4), pp. 338–362. DOI: 10.1080/03670240802003850.

Chadare, F. J.; Madode, Y. E.; Fanou-Fogny, N.; Kindossi, J. M.; Ayosso, J. O.; Honfo, S. H. et al. (2018): Indigenous food ingredients for complementary food formulations to combat infant malnutrition in Benin: a review. In *Journal of the Science of Food and Agriculture* 98 (2), pp. 439–455. DOI: 10.1002/jsfa.8568.

Chadwick, P. M.; Crawford, C.; Ly, L. (2013): Human food choice and nutritional interventions. In *Nutrition Bulletin* 38 (1), pp. 36–42. DOI: 10.1111/nbu.12005.

Charles, N.; Kerr, M. (1988): Women, food, and families: Manchester University Press.

Chivenge, P.; Mabhaudi, T.; Modi, A. T.; Mafongoya, P. (2015): The Potential Role of Neglected and Underutilised Crop Species as Future Crops under Water Scarce Conditions in Sub-Saharan Africa. In *International journal of environmental research and public health* 12 (6), pp. 5685–5711. DOI: 10.3390/ijerph120605685.

Christenhusz, M. J. M.; Byng, J. W. (2016): The number of known plants species in the world and its annual increase. In *Phytotaxa* 261 (3), p. 201. DOI: 10.11646/phytotaxa.261.3.1.

Cloete, P. C.; Idsardi, E. F. (2013): Consumption of Indigenous and Traditional Food Crops: Perceptions and Realities from South Africa. In *Agroecology and Sustainable Food Systems* 37 (8), pp. 902–914. DOI: 10.1080/21683565.2013.805179.

Codjia, J. T. C.; Assogbadjo, A. E.; Ekué, M. R. M. (2003): Diversité et valorisation au niveau local des ressources végétales forestières alimentaire du Bénin. In *Cahiers agricultures* 12, pp. 1–2.

Cook, J. A.; VanderJagt, D. J.; Pastuszyn, A.; Mounkaila, G.; & Glew, R. H. (1998): Nutrient Content of Two Indigenous Plant Foods of the Western Sahel: Balanites aegyptiaca and Maerua crassifolia. In *Journal of food composition and analysis* 11 (3), pp. 221–230.

Dansi, A.; Adjatin, A.; Adoukonou-Sagbadja, H.; Faladé, V.; Yedomonhan, H.; Odou, D.; Dossou, B. (2008): Traditional leafy vegetables and their use in the Benin Republic. In *Genet Resour Crop Evol* 55 (8), pp. 1239–1256. DOI: 10.1007/s10722-008-9324-z.

Dansi, A.; Vodouhè, R.; Azokpota, P.; Yedomonhan, H.; Assogba, P.; Adjatin, A. et al. (2012): Diversity of the neglected and underutilized crop species of importance in Benin. In *The Scientific World Journal* 2012, p. 932947. DOI: 10.1100/2012/932947.

Davis, A.; Wagner, J. R. (2003): Who knows? On the importance of identifying “experts” when researching local ecological knowledge. In *Human Ecology* 31 (3), pp. 463–489.

Delormier, T.; Frohlich, K. L.; Potvin, L. (2009): Food and eating as social practice--understanding eating patterns as social phenomena and implications for public health. In *Sociology of health & illness* 31 (2), pp. 215–228. DOI: 10.1111/j.1467-9566.2008.01128.x.

DeSouza, S. (2008): Flore du Benin: Nom des plantes dans les langues nationales Beninoises. Tunde, Cotonou, Benin.

Dinssa, F. F.; Hanson, P.; Dubois, T.; Tenkouano, A.; Stoilova, T.; Hughes, J.d'A.; Keatinge, J.D.H. (2016): AVRDC - The World Vegetable Center's women-oriented improvement and development strategy for traditional African vegetables in sub-Saharan Africa. In *Europ.J.Hortic.Sci.* 81 (2), pp. 91–105. DOI: 10.17660/eJHS.2016/81.2.3.

Dossou, M. K. R.; Codjia, J. T. C.; Biaou, G. (2004): Rôle de la ressource forestiere Blighia sapida (ackee ou faux acajou) dans l’économie des ménages du Nord-Ouest du Bénin. In *Bulletin de la Recherche Agronomique du Bénin* 46, pp. 33–41.

Doucerain, M.; Fellows, L. K. (2012): Eating right: Linking food-related decision-making concepts from neuroscience, psychology, and education. In *Mind, Brain and Education* 6 (4), pp. 206–219.

Downs, S. M.; Ahmed, S.; Fanzo, J.; Herforth, A. (2020): Food Environment Typology: Advancing an Expanded Definition, Framework, and Methodological Approach for Improved Characterization of Wild, Cultivated, and Built Food Environments toward Sustainable Diets. In *Foods (Basel, Switzerland)* 9 (4). DOI: 10.3390/foods9040532.

Ebert, A. (2014): Potential of Underutilized Traditional Vegetables and Legume Crops to Contribute to Food and Nutritional Security, Income and More Sustainable Production Systems. In *Sustainability* 6 (1), pp. 319–335. DOI: 10.3390/su6010319.

Edame, G. E.; Ekpenyong, A. B.; Fonta, W. M.; Duru, E. J. C. (2011): Climate change, food security and agricultural productivity in Africa: issues and policy directions. In *International journal of humanities and social science* 1 (21), pp. 205–223.

Edwards, K.; Lund, C.; Gibson, N. (2008): Ethical validity: Expecting the unexpected in community-based research. In *Pimatisiwin: A Journal of Aboriginal & Indigenous Community Health* 6 (3).

Ekué, M. R.; Sinsin, B.; Eyog-Matig, O.; Finkeldey, R. (2010): Uses, traditional management, perception of variation and preferences in ackee (Blighia sapida K.D. Koenig) fruit traits in Benin: implications for domestication and conservation. In *Journal of ethnobiology and ethnomedicine* 6 (1).

Ekué, M. R. M.; Assogbadjo, A. E.; Mensah, G. A.; Codjia, J. T. C. (2004): Aperçu sur la distribution écologique et le système agroforestier traditionnel autour de l'ackée (Blighia sapida) en milieu soudanien au Nord Bénin. In *Bulletin de la Recherche Agronomique du Bénin* 44 (34-44).

Ericksen, P.; Stewart, B.; Dixon, J.; d. Barling; Loring, P.; Anderson, M.; Ingram, J. (2012): The value of a food system approach. In *Food security and global environmental change*, pp. 25–45.

Ericksen, P. J. (2008): Conceptualizing food systems for global environmental change research. In *Global Environmental Change* 18 (1), pp. 234–245. DOI: 10.1016/j.gloenvcha.2007.09.002.

Fandohan, B.; Assogbadjo, A. E.; Kakaï, R. G.; Kyndt, T.; Caluwé, E. de; Codjia, J. T. C.; Sinsin, B. (2010): Women's Traditional Knowledge, Use Value, and the Contribution of Tamarind (Tamarindus indica L.) to Rural Households' Cash Income in Benin. In *Econ Bot* 64 (3), pp. 248–259.

Fanzo, J.; Holmes, M.; Junega, P.; Musinguzi, E.; Smith, I. F.; Ekesa, B.; Bergamini, N. (2011): Improving nutrition with agricultural biodiversity. A manual on implementing food systems field projects to assess and improve dietary diversity, and nutrition and health outcomes. In *Bioversity International (Rome, Italy)*.

Fanzo, J.; Hunter, D.; Borelli, T.; Mattei, F. (Eds.) (2013): Diversifying food and diets. Using agricultural biodiversity to improve nutrition and health. First edition. London, New York: Earthscan from Routledge (Issues in agricultural biodiversity).

FAO (2011): Profil nutritionnel de pays: République du Bénin. Division de la Nutrition et de la Protection des Consommateurs.

FAO; IFAD; UNICEF; WFP; WHO (2019): The State of Food Security and Nutrition in the World 2019. Safeguarding against economic slowdowns and downturns. Available online at http://www.fao.org/3/ca5162en/ca5162en.pdf.

Fentahun, M. T.; Hager, H. (2009): Exploiting locally available resources for food and nutritional security enhancement: wild fruits diversity, potential and state of exploitation in the Amhara region of Ethiopia. In *Food Sec.* 1 (2), pp. 207–219. DOI: 10.1007/s12571-009-0017-z.

Fogny, N. F.; Trentmann, C. (2016): Enquête de référence sur la nutrition - Bénin. Pour le programme mondiale Sécurité alimentaire et renforcement de la résilience.

Frewer, L.; van Trijp, H. (Eds.). (2006): Understanding consumers of food products: Woodhead Publishing.

Furst, T.; Connors, M.; Bisogni, C. A.; Sobal, J.; Falk, L. W. (1996): Food choice: a conceptual model of the process. In *Appetite* 26 (3), pp. 247–266.

Fuster, M.; Messer, E.; Houser, R. F.; Deman, H.; Fulladolsa, P. P.; Bermudez, O. I. (2013): Local Notions of Healthy Eating and National Dietary Guidelines: A Comparison in

Vulnerable Salvadoran Communities. In *Food and Foodways* 21 (4), pp. 288–314. DOI: 10.1080/07409710.2013.850002.

Gandji, K.; Salako, V. K.; Fandohan, A. B.; Assogbadjo, A. E.; Glèlè Kakaï, R. L. (2018): Factors Determining the Use and Cultivation of Moringa oleifera Lam. in the Republic of Benin. In *Econ Bot* 72 (3), pp. 332–345. DOI: 10.1007/s12231-018-9424-4.

Gaoue, O. G.; Ticktin, T. (2009): Fulani knowledge of the ecological impacts of Khaya senegalensis (Meliaceae) foliage harvest in Benin and its implications for sustainable harvest. In *Economic Botany* 63 (3), pp. 256–270.

Garn, S. M.; Leonard, W. R. (1989): What Did Our Ancestors Eat? In *Nutrition Reviews* 47 (11), pp. 337–345.

Grace, D. (2016): Influencing food environments for healthy diets through food safety, 43-75.

Guin, Y.; Lemessa, L. (2000): Wild-food Plants in Southern Ethiopia. Reflections on the role of famine-foods at a time of drought.

Halkier, B.; Jensen, I. (2011): Methodological challenges in using practice theory in consumption research. Examples from a study on handling nutritional contestations of food consumption. In *Journal of Consumer Culture* 11 (1), pp. 101–123. DOI: 10.1177/1469540510391365.

Hanazaki, N.; Herbst, D. F.; Marques, M. S.; Vandebroek, I. (2013): Evidence of the shifting baseline syndrome in ethnobotanical research. In *Journal of ethnobiology and ethnomedicine* 9 (1).

Hawkes, C. (2006): Uneven dietary development: linking the policies and processes of globalization with the nutrition transition, obesity and diet-related chronic diseases. In *Globalization and health* 2, p. 4. DOI: 10.1186/1744-8603-2-4.

Hawtin, G. (2007): Underutilized plant species research and development activities–review of issues and options. A report submitted to the chairs of the GFU Steering Committee and the ICUC Scientific Advisory Board, 1-8.

Herforth, A.; Ahmed, S. (2015): The food environment, its effects on dietary consumption, and potential for measurement within agriculture-nutrition interventions. In *Food Sec.* 7 (3), pp. 505–520. DOI: 10.1007/s12571-015-0455-8.

Herforth, A.; Ahmed, S.; Declerck, F.; Fanzo, J.; Remans, R. (2017): Creating sustainable, resilient food systems for healthy diets. In *UNSCN News* 42, pp. 15–22.

Holm, L. (2016): Alan, Warde, 2016, The practice of eating, Polity. Book Review. In *Rev Agric Food Environ Stud* 97 (4), pp. 277–279. DOI: 10.1007/s41130-016-0031-4.

Homer, P. M.; Kahle, L. R. (1998): A structural equation test of the value-attitude behaviour hierarchy. In *Journal of Personality and Social Psychology* 54, pp. 638–646.

Hughes, J. D. A.; Ebert, A. W. (2011): Research and development of underutilized plant species: the role of vegetables in assuring food and nutritional security. In *Acta Hortic.* 979, pp. 79–92.

Hunter, D.; Borelli, T.; Beltrame, D. M. O.; Oliveira, C. N. S.; Coradin, L.; Wasike, V. W. et al. (2019): The potential of neglected and underutilized species for improving diets and nutrition. In *Planta*. DOI: 10.1007/s00425-019-03169-4.

Hunter-Adams, J.; Rother, H.-A. (2016): Pregnant in a foreign city: A qualitative analysis of diet and nutrition for cross-border migrant women in Cape Town, South Africa. In *Appetite* 103, pp. 403–410. DOI: 10.1016/j.appet.2016.05.004.

Hunter-Adams, J. (2017): Exploring Perceptions of the Food Environment Amongst Congolese, Somalis and Zimbabweans Living in Cape Town. In *Int Migr* 55 (4), pp. 78–87. DOI: 10.1111/imig.12274.

Igumbor, E. U.; Sanders, D.; Puoane, T. R.; Tsolekile, L.; Schwarz, C.; Purdy, C. et al. (2012): "Big food," the consumer food environment, health, and the policy response in South Africa. In *PLoS Med* 9 (7). DOI: 10.1371/journal.pmed.1001253.t001.

INSAE (2016): Effectifs de la poulations des villages et quartiers de ville du Benin. RGPH-4, 2013.

INSAE; ICF (2019): Bénin. Enquête Démographique et de Santé 2017-2018. Institut National de la Statistique et de l'Analyse Économique.

Jaccard, J.; Wood, G. (1986): An Idiothetic Analysis of Behavioral Decision Making. D. Brinberg et al. (eds.), Perspectives on Methodology in Consumer Research.

Jaenicke, H.; Höschle-Zeledon, I. (2006): Strategic Framework for Underutilized Plant Species Research and Development, with Special Reference to Asia and the Pacific, and to Sub-Saharan Africa. In *Bioversity International*.

Johns, T.; Eyzaguirre, P. B. (2006): Linking biodiversity, diet and health in policy and practice. Symposium on 'Wild-gathered plants: basic nutrition, health and survival'. In *Proc. Nutr. Soc.* 65 (2), pp. 182–189. DOI: 10.1079/PNS2006494.

Kearney, J. (2010): Food consumption trends and drivers. In *Philosophical transactions of the Royal Society of London. Series B, Biological sciences* 365 (1554), pp. 2793–2807. DOI: 10.1098/rstb.2010.0149.

Keatinge, J. D. H.; Easdown, W. J.; Yang, R. Y.; Chadha, M. L.; Shanmugasundaram, S. (2011): Overcoming chronic malnutrition in a future warming world: the key importance of mungbean and vegetable soybean. In *Euphytica* 180 (1), pp. 129–141. DOI: 10.1007/s10681-011-0401-6.

Keatinge, J. D. H.; Waliyar, F.; Jamnadas, R. H.; Moustafa, A.; Andrade, M.; Drechsel, P. et al. (2010): Relearning Old Lessons for the Future of Food—By Bread Alone No Longer: Diversifying Diets with Fruit and Vegetables. In *Crop Science* 50 (Supplement_1), S-51. DOI: 10.2135/cropsci2009.09.0528.

Keegan, W. F. (1986): The Optimal Foraging Analysis of Horticultural Production. In *American Anthropologist* 88 (1), pp. 92–107. DOI: 10.1525/aa.1986.88.1.02a00060.

Khoury, C. K.; Bjorkman, A. D.; Dempewolf, H.; Ramirez-Villegas, J.; Guarino, L.; Jarvis, A. et al. (2014): Increasing homogeneity in global food supplies and the implications for food security. In *Proceedings of the National Academy of Sciences of the United States of America* 111 (11), pp. 4001–4006. DOI: 10.1073/pnas.1313490111.

Kinkingninhoun-Mêdagbé, F. M.; Diagne, A.; Simtowe, F.; Agboh-Noameshie, A. R.; Adégbola, P. Y. (2010): Gender discrimination and its impact on income, productivity, and technical efficiency: evidence from Benin. In *Agric Hum Values* 27 (1), pp. 57–69. DOI: 10.1007/s10460-008-9170-9.

Köster, E. P. (2009): Diversity in the determinants of food choice: A psychological perspective. In *Food Quality and Preference* 20, pp. 70–82.

Kouyaté, A. M.; Lamien, N. (2011): Detarium microcarpum, sweet detar. Conservation and Sustainable Use of Genetic Resources of Priority Food Tree Species in sub-Saharan Africa. In *Bioversity International (Rome, Italy)*.

Krueger, R. A.; Casey, M. A. (2014): Focus groups: A practical guide for applied research. 5th ed.: Sage publications, Inc.

Kuhnlein, H. V.; Erasmus, B.; Spigelski, D. (2009): Indigenous peoples' food systems. The many dimensions of culture, diversity and environment for nutrition and health. Reprinted. Rome, Quebec: Food and Agriculture Organization of the United Nations; Centre for Indigenous Peoples' Nutrition and Environment.

Kuhnlein, H. V.; Erasmus, B.; Spigelski, D.; Burlingame, B. (2013): Indigenous peoples' food systems & well-being. Interventions & policies for healthy communities. Rome, Ste. Anne de Bellevue Quebec: Food and Agriculture Organization of the United Nations; Centre for Indigenous Peoples' Nutrition and Environment.

Kuhnlein, H. V.; Pelto, G. H. (1997): Culture, environment and food to prevent vitamin A deficiency: INFDC AND IDRC.

Kuhnlein, H. V.; Receveur, O. (1996): Dietary Change and Traditional Food Systems of Indigenous Peoples. In *Annual Review of Nutrition* 16 (1), pp. 417–442.

Lamien, N.; Ekué, M.; Ouedraogo, M.; Loo, J. (2011): Parkia biglobosa, néré. Conservation et utilisation durable des ressources génétiques des espèces ligneuses alimentaires prioritaires de l'Afrique subsaharienne. In *Bioversity International (Rome, Italie)*.

Lang, T.; Rayner, G. (2007): Overcoming policy cacophony on obesity: an ecological public health framework for policymakers. In *Obesity reviews* 8 (1), pp. 165–181.

Liamputtong, P. (Ed.) (2008): Doing Cross-Cultural Resarch. Language and Communication in Cross-Cultural Qualitative Research. With assistance of M. M. Hennink: Springer Science + Business Media.

Lokonon, B. E.; Tchandao Mangamana, E.; Gnonlonfoun, I.; Akpona, T. J. D.; Assogbadjo, A. E.; Glèlè Kakaï, R.; Sinsin, B. (2018): Knowledge, valuation and prioritization of 46 woody species for conservation in agroforestry systems along Ouémé catchment in Benin (West Africa). In *Environ Dev Sustain* 48 (2), p. 245. DOI: 10.1007/s10668-018-0142-y.

Lowore, J. (2001): Natural Resource Based Enterprises in Malawi: Study on the Contribution of NRBEs to Economic Development and Community-based Natural Resource Management in Machinga District. Community Partnerships for Sustainable Resource Management in Malawi. In *COMPASS document* 29.

Maitra, C. (2018): A review of studies examining the link between food insecurity and malnutrition. Technical paper. Available online at http://www.fao.org/3/CA1447EN/ca1447en.pdf.

Matenge, S. T. P.; van der Merwe, D.; Beer, D.; Bosman, M. J. C.; Kruger, A. (2012): Consumers'beliefs on indigenous and traditional foods and acceptance of productsmade with cowpea leaves. In *African Journal of Agricultural Research* 7 (12), pp. 2243–2254.

Maxwell, S.; Slater, R. (2003): Food policy old and new. In *Development policy review* 21 (5-6), pp. 531–533.

Mayes, S.; Basu, S.; Murchie, E.; Roberts, J. A.; Azam-Ali, S. N.; Stadler, F. et al. (2009): BAMLINK-a cross disciplinary programme to enhance the role of Bambara groundnut (Vigna subterranea l. Verdc.) for food security in Africa and India. In *Acta Hortic.* (806), pp. 137–150.

Mayes, S.; Massawe, F. J.; Alderson, P. G.; Roberts, J. A.; Azam-Ali, S. N.; Hermann, M. (2012): The potential for underutilized crops to improve security of food production. In *Journal of experimental botany* 63 (3), pp. 1075–1079. DOI: 10.1093/jxb/err396.

Mayring, P. (2007): Qualitative Inhaltsanalyse: Grundlagen und Techniken. 11., aktualisierte und überarbeitete Auflage: Weinheim und Basel: Beltz Verlag.

McClatchey, W.; Gollin, L. X. (2005): An ethnobotany research training workshop in Madagascar. In *Ethnobotany Research and Applications* 3, pp. 309–328.

McMullin, S.; Stadlmayr, B.; Roothaert, R.; Jamnadass, R. (2019): Fresh Fruit and Vegetables: Contributions to Food and Nutrition Security. In *Elsevier*.

Mela, D. J. (1999): Food choice and intake: the human factor. In *Proc. Nutr. Soc.* 58 (3), pp. 513–521. DOI: 10.1017/S0029665199000683.

Mintz, S. W.; Du Bois, C. M. (2002): The anthropology of food and eating. In *Annual review of anthropology* 31, pp. 99–119.

Modi, M.; Modi, A.; Hendriks, S. (2006): Potential role for wild vegetables in household food security: a preliminary case study in Kwazulu-Natal, South Africa. In *African Journal of Food, Agriculture, Nutrition and Development* 6 (1), pp. 1–13.

Muhammad, S.; Amusa, N. A. (2003): Distribution and socio-economics of two leguminous tree species in Guinea and Suddan Savanna Agro-ecologies of Nigeria. In *Journal of Agricultural Sciences* 2 (2), pp. 122–126.

Muller, J.; Almedom, A. M. (2008): What is “Famine Food”? Distinguishing Between Traditional Vegetables and Special Foods for Times of Hunger/Scarcity (Boumba, Niger). In *Hum Ecol* 36 (4), pp. 599–607. DOI: 10.1007/s10745-008-9179-0.

Müller-Schwarze, N. K. (2006): Antes and Hoy Día: plant knowledge and categorization as adaptations to life in Panama in the twenty-first century. In *Ecnomic Botany* 60 (4), pp. 321–334.

Nestle, M.; Wing, R.; Birch, L.; DiSogra, L.; Drewnowski, A.; Middleton, S. et al. (1998): Behavioral and Social Influences on Food Choice. In *Nutrition Reviews* 56 (5), S50-S74.

Neuman, N. (2019): On the engagement with social theory in food studies: cultural symbols and social practices. In *Food, Culture & Society* 22 (1), pp. 78–94. DOI: 10.1080/15528014.2018.1547069.

O’Neill, K. J.; Clear, A. K.; Friday, A.; Hazas, M. (2019): ‘Fractures’ in food practices: exploring transitions towards sustainable food. In *Agric Hum Values* 36 (2), pp. 225–239. DOI: 10.1007/s10460-019-09913-6.

Ojelel, S.; Mucunguzi, P.; Katuura, E.; Kakudidi, E. K.; Namaganda, M.; Kalema, J. (2019): Wild edible plants used by communities in and around selected forest reserves of Teso-Karamoja region, Uganda. In *Journal of ethnobiology and ethnomedicine* 15 (1), p. 3. DOI: 10.1186/s13002-018-0278-8.

Olsen, S. O. (1999): Strength and conflicting valence in the measurement of food attitudes and preferences. In *Food Quality and Preference* 10 (6), pp. 483–494.

Oluwatayo, I. B.; Ojo, A. O. (2014): Socioeconomic Contributions of Neglected and Underutilized Species to Livelihood Security in Rural Southwest Nigeria: Thaumatococcus Danielli as a Test Case. In *MJSS*. DOI: 10.5901/mjss.2014.v5n27p311.

Padulosi, S. (2013): Fighting poverty, hunger and malnutrition with neglected and underutilized species (NUS). Needs, challenges and the way forward.

Padulosi, S.; Cawthorn, D. M.; Meldrum, G.; Flore, R.; Halloran, A.; Mattei, F. (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: Elsevier, pp. 361–370.

Padulosi, S.; Heywood, V.; Hunter, D.; Jarvis, A. (2011): Underutilized species and climate change: current status and outlook. In *Crop adaptation to climate change*, pp. 507–521.

Padulosi, S.; Hodgkin, T.; Williams, J. T.; Haq, N. (2002): Underutilized crops: trends, challenges and opportunities in the 21st century. In *CAB International, Wallingford*.

Padulosi, S.; Hoeschle-Zeledon, I. (2004): Underutilized plant species: what are they? In *Nutrition Bulletin*.

Padulosi, S.; Mal, B.; King, O.; Gotor, E. (2015): Minor Millets as a Central Element for Sustainably Enhanced Incomes, Empowerment, and Nutrition in Rural India. In *Sustainability* 7 (7), pp. 8904–8933. DOI: 10.3390/su7078904.

Palojoki, P.; Tuomi-Gröhn, T. (2001): The complexity of food choices in an everyday context. In *International Journal of Consumer Studies* 25 (1), pp. 15–23.

Pawera, L.; Khomsan, A.; Zuhud, E. A. M.; Hunter, D.; Ickowitz, A.; Polesny, Z. (2020): Wild Food Plants and Trends in Their Use: From Knowledge and Perceptions to Drivers of Change in West Sumatra, Indonesia. In *Foods (Basel, Switzerland)* 9 (9). DOI: 10.3390/foods9091240.

Penafiel, D.; Lachat, C.; Espinel, R.; van Damme, P. K. P. (2011): A systematic review on the contributions of edible plant and animal biodiversity to human diets. In *EcoHealth* 8 (3), pp. 381–399. DOI: 10.1007/s10393-011-0700-3.

Pilgrim, S. E.; Cullen, L. C.; Smith, D. J.; Pretty, J. (2008): Ecological Knowledge is Lost in Wealthier Communities and Countries. In *Environ. Sci. Technol.* 42 (4), pp. 1004–1009. DOI: 10.1021/es070837v.

Pinstrup-Andersen, P. (2012): The food system and its interaction with human health and nutrition. In *Reshaping agriculture for nutrition and health* 21.

Plant Resources of Tropical Africa (2010): Promising African plants. A selection from the PROTA programme.

Poland, B.; Frohlich, K.; Haines, R. J.; Mykhalovskiy, E.; Rock, M.; Sparks, R. (2006): The social context of smoking: the next frontier in tobacco control? In *Tobacco control* 15 (1), pp. 59–63. DOI: 10.1136/tc.2004.009886.

Popkin, B. M. (2004): The Nutrition Transition: An Overview of World Patterns of Change. In *Nut. Rev.* 62 (7), pp. 140–143. DOI: 10.1301/nr.2004.jul.S140-S143.

Popkin, B. M. (2015): Nutrition Transition and the Global Diabetes Epidemic. In *Current diabetes reports* 15 (9), p. 64. DOI: 10.1007/s11892-015-0631-4.

Popkin, B. M.; Corvalan, C.; Grummer-Strawn, L. M. (2020): Dynamics of the double burden of malnutrition and the changing nutrition reality. In *The Lancet* 395 (10217), pp. 65–74. DOI: 10.1016/S0140-6736(19)32497-3.

Powell, B.; Bezner Kerr, R.; Young, S. L.; Johns, T. (2017): The determinants of dietary diversity and nutrition: ethnonutrition knowledge of local people in the East Usambara Mountains, Tanzania. In *Journal of ethnobiology and ethnomedicine* 13 (1), p. 23. DOI: 10.1186/s13002-017-0150-2.

Powell, B.; Thilsted, S. H.; Ickowitz, H.; Termote, C.; Sunderland, T.; Herforth, A. (2015): Improving diets with wild and cultivated biodiversity from across the landscape. In *Food Sec.* 7 (3), pp. 535–554. DOI: 10.1007/s12571-015-0466-5.

Quinlan, M. B.; Quinlan, R. J. (2007): Modernization and Medicinal Plant Knowledge in a Caribbean Horticultural Village. In *maq* 21 (2), pp. 169–192. DOI: 10.1525/maq.2007.21.2.169.

Quintanilha, M.; Mayan, M. J.; Thompson, J.; Bell, R. C. (2015): Different Approaches to Cross-Lingual Focus Groups. In *International journal of qualitative methods* 14 (5), 160940691562141. DOI: 10.1177/1609406915621419.

Quiroz, D.; van Andel, T. (2015): Evidence of a link between taboos and sacrifices and resource scarcity of ritual plants. In *Journal of ethnobiology and ethnomedicine* 11 (1).

Raneri, J. E.; Padulosi, S.; Meldrum, G.; King, O. I. (2019): Supply-side measures improving food environments. Promoting neglected and underutilized species to boost nutrition in LMICs. In *UNSCN News* 44, pp. 10–25.

RBG, Kew: Plants of the world online. Kew Science. Edited by Kew Royal Botanic Gardens. Available online at http://www.plantsoftheworldonline.org/taxon/urn:lsid:ipni.org:names:60518-2, checked on 10/18/2020.

Reckwitz, A. (2002): Toward a Theory of Social Practices. In *European Journal of Social Theory* 5 (2), pp. 243–263. DOI: 10.1177/13684310222225432.

Relique, A. I.; Abel, M. A.; Rollande, D. A.; Assogbadjo, A. E.; Agbangla, C. (2018): Morphological Variability of Detarium microcarpum Guill. & Perr. (Caesalpiniaceae) in Benin, West Africa. In *AJRAF* 1 (2), pp. 1–12. DOI: 10.9734/AJRAF/2018/41234.

Reyes-García, Victoria; Menendez-Baceta, Gorka; Aceituno-Mata, Laura; Acosta-Naranjo, Rufino; Calvet-Mir, Laura; Domínguez, Pablo et al. (2015): From famine foods to delicatessen: Interpreting trends in the use of wild edible plants through cultural ecosystem services. In *Ecological Economics* 120, pp. 303–311. DOI: 10.1016/j.ecolecon.2015.11.003.

Ricciardi, V.; Ramankutty, N.; Mehrabi, Z.; Jarvis, L.; Chookolingo, B. (2018): How much of the world's food do smallholders produce? In *Global food security* 17, pp. 64–72. DOI: 10.1016/j.gfs.2018.05.002.

Røpke, I. (2009): Theories of practice — New inspiration for ecological economic studies on consumption. In *Ecological Economics* 68 (10), pp. 2490–2497. DOI: 10.1016/j.ecolecon.2009.05.015.

Rosenberg, M. J.; Hovland, C. I. (1960): Cognitive, affective, and behavioral components of attitudes. In M. J. Rosenberg et al. (Eds.), Attitude organization and change. In *Yale Univ. Press*, pp. 1–14.

Royal Botanic Gardens Kew (2016): The state of the world's plants report 2016. In *Royal Botanic Gardens Kew*.

Rozin, P. (1996): The socio-cultural context of eating and food choice. In Food choice, acceptance and consumption, pp. 83–104.

Ryan, Gery W.; Bernard, H. Russell (2003): Techniques to Identify Themes. In *Field Methods* 15 (1), pp. 85–109. DOI: 10.1177/1525822X02239569.

Savy, M.; Martin-Prével, Y.; Traissac, P.; Eymard-Duvernay, S.; Delpeuch, F. (2006): Dietary Diversity Scores and Nutritional Status of Women Change during the Seasonal Food Shortage in Rural Burkina Faso. In *The Journal of Nutrition* 136 (10), pp. 2625–2632.

Schippers, R. R. (2000): African indigenous vegetables. An overview of the cultivated species.

Schmidt, M.; Lam, N. T.; Hoanh, M. T.; Padulosi, S.; Quy, G. L. (2010): Promoting neglected and underutilised tuberous plant species in Vietnam (183-189).

Shackleton, C. M.; Pasquini, M. W.; Drescher, A. W. (Eds.) (2009): Biodiversity of African vegetables. With assistance of P. Maundu, E. Achigan-Dako, Y. Morimoto: Earthscan from Routledge (In African Indigenous Vegetables in Urban Agriculture).

Shepherd, D. (1985): Dietary salt intake. In *Nutrition & Food Science* 85 (5), pp. 10–11. DOI: 10.1108/eb059082.

Shepherd, R. (1999): Social determinants of food choice. Shepherd, R. (1999). Social determinants of food. In *Proc. Nutr. Soc.* 58 (4), pp. 807–812.

Shepherd, R. (2001): Does taste determine consumption? Understanding the psychology of food choice. In Food, people and society, pp. 117–130.

Sobal, J.; Bisogni, C. A. (2009): Constructing food choice decisions. In *Annals of behavioral medicine: a publication of the Society of Behavioral Medicine* 38 Suppl 1, S37-46. DOI: 10.1007/s12160-009-9124-5.

Sobal, J.; Bisogni, C. A.; Jastran, M. (2014): Food choice is multifaceted, contextual, dynamic, multilevel, integrated, and diverse. In *Mind, Brain and Education* 8 (1), pp. 6–12.

Sodjinou, R.; Agueh, V.; Fayomi, B.; Dlisle, H. (2009): Dietary patterns of urban adults in Benin: relationship with overall diet quality and socio-demographic characteristics. In *European journal of clinical nutrition* 63 (2), pp. 222–228.

Southerton, D. (2013): Habits, routines and temporalities of consumption: From individual behaviours to the reproduction of everyday practices. In *Time & Society* 22 (3), pp. 335–355.

Souto, T.; Ticktin, T. (2012): Understanding interrelationships among predictors (age, gender, and origin) of local ecological knowledge. In *Economic Botany* 66 (2), pp. 149–164.

Squires, A. (2009): Methodological challenges in cross-language qualitative research: a research review. In *International journal of nursing studies* 46 (2), pp. 277–287. DOI: 10.1016/j.ijnurstu.2008.08.006.

Story, M.; Kaphingst, K. M.; Robinson-O'Brien, R.; Glanz, K. (2008): Creating healthy food and eating environments: policy and environmental approaches. In *Annual review of public health* 29, pp. 253–272. DOI: 10.1146/annurev.publhealth.29.020907.090926.

Thakur, D.; Sharma, A.; Uniyal, S. K. (2017): Why they eat, what they eat: patterns of wild edible plants consumption in a tribal area of Western Himalaya. In *Journal of ethnobiology and ethnomedicine* 13 (1), p. 70. DOI: 10.1186/s13002-017-0198-z.

Torimiro, D. O.; Odeyinka, S. M.; Okorie, V. O.; Akinsuyi, M. A. (2009): Gender analysis of socio-cultural perception of Moringa oleifera amongst farmers in Southwestern Nigeria. In *Journal of International Women's Studies* 10 (4), pp. 188–202.

Turner, C.; Aggarwal, A.; Walls, H.; Herforth, A.; Drewnowski, A.; Coates, J. et al. (2018): Concepts and critical perspectives for food environment research: A global framework with implications for action in low- and middle-income countries. In *Global food security* 18, pp. 93–101. DOI: 10.1016/j.gfs.2018.08.003.

Turner, C.; Kalamatianou, S.; Drewnowski, A.; Kulkarni, B.; Kinra, S.; Kadiyala, S. (2020): Food Environment Research in Low- and Middle-Income Countries: A Systematic Scoping Review. In *Advances in nutrition (Bethesda, Md.)* 11 (2), pp. 387–397. DOI: 10.1093/advances/nmz031.

UNICEF (2013): Improving child nutrition. The achievable imperative for global progress. New York: United Nations Children's Fund (UNICEF).

Vabø, M.; Hansen, H. (2014): The relationship between food preferences and food choice: a theoretical discussion. In *International Journal of Business and Social Science* 5 (7).

van Andel, T. (2006): Non-timber forest products. The value of wild plants. In *Agrodok* 39.

van Liere, M. J.; Ategbo, E. A. D.; Den Hartog, A. P.; Hautvast, G. A. J. (1995): The Consequences of Seasonal Food Insecurity for Individual Food-Consumption Patterns in North-Western Benin. In *Food and nutrition bulletin* 16 (2), pp. 1–8.

Vodouhê, F. G.; Coulibaly, O.; Greene, C.; & Sinsin, B. (2009): Estimating the local value of non-timber forest products to pendjari biosphere reserve dwellers in Benin. In *Economic Botany* 63 (4), pp. 397–412.

Wade, R. H. (2003): What strategies are viable for developing countries today? The World Trade Organization and the shrinking of ‘development space’. In *Review of international political economy* 10 (4), pp. 621–644.

Wądołowska, L.; Babicz-Zielińska, E.; Czarnocińska, J. (2008): Food choice models and their relation with food preferences and eating frequency in the Polish population: POFPRES study. In *Food Policy* 33 (2), pp. 122–134. DOI: 10.1016/j.foodpol.2007.08.001.

Wahlqvist, M. L.; Lee, M. S. (2007): Regional food culture and development. Asia Pacific journal of clinical nutrition. In *Asia Pacific journal of clinical nutrition* 16 (1), pp. 2–7.

Warde, A. (2005): Consumption and theories of practice. In *Journal of Consumer Culture* 5 (2), pp. 131–153.

Warde, A. (2016): After taste: Culture, consumption and theories of practice. In *Journal of Consumer Culture* 14 (3), pp. 279–303.

Wiersema, J. H.; León; B. (1999): World economic plants: a standard reference. In *CRC Press*.

Willett, W.; Rockström, J.; Loken, B.; Springmann, M.; Lang, T.; Vermeulen, S. et al. (2019): Food in the Anthropocene: the EAT–Lancet Commission on healthy diets from sustainable food systems. In *The Lancet* 393 (10170), pp. 447–492. DOI: 10.1016/S0140-6736(18)31788-4.

Williams, J. T.; Haq, N. (2002): Global research on underutilised crops - an assessment of current activities and proposals for enhanced cooperation. In *Bioversity International*.

World development indicators database (2019): Country profile Benin. Available online at https://databank.worldbank.org/views/reports/reportwidget.aspx?Report_Name=CountryProfile&Id=b450fd57&tbar=y&dd=y&inf=n&zm=n&country=BEN, checked on 05112020.

Wright, T.; Nancarrow, C.; Kwok, P. M.H. (2001): Food taste preferences and cultural influences on consumption. In *British Food Journal* 103 (5), pp. 348–357. DOI: 10.1108/00070700110396321.

10. List of figures

11. List of tables

12. List of photos

13. Annex

13.1. Photographs

Photo 2 Example of photocollage of *A. digitata (source of photos: Antenner et al. 2007/2008)*

13.2. Information sheet and consent form

NOTE D'INFORMATION

Titre de l'étude : Accroitre la demande des consommateurs et l'utilisation d'espèces de plantes nutritives sous-utilisées dans l'alimentation des populations du Nord-Bénin

Date : 1er septembre 2019

A qui est destiné cette note d'information : A tous les participants à l'étude.

Lieu d'administration : Cette note d'information sera présentée sur les lieux des entretiens : aux domiciles des participants dans le cas des entretiens individuels dans les villages, sur les lieux des discussions de groupes dans le cas des discussions en groupe et sur les lieux de travail dans le cas des entretiens avec les professionnels.

Quelle est la nature de ce projet?

Grâce à ce projet, le rôle de la biodiversité alimentaire locale dans l'amélioration de la nutrition dans le nord du Bénin sera mieux compris et exploité pour améliorer la qualité de l'alimentation, sur la base de 10 espèces de plantes comestibles disponibles, sous-utilisées et nutritives. L'objectif du projet est de sensibiliser davantage les consommateurs au potentiel nutritionnel des espèces végétales comestibles sous-utilisées et les motiver à intégrer ces espèces dans leur alimentation. Les travaux renforceront les capacités des agents de vulgarisation agricole et des agents de santé et des ONG locales afin de mieux reconnaitre le potentiel nutritionnel de ces espèces végétales et de les promouvoir au cours de leurs activités éducatives. Lorsqu'on examine le potentiel d'espèces particulières pour améliorer la qualité alimentaire d'une communauté, davantage de facteurs que les caractéristiques nutritionnelles de ces espèces jouent un rôle. Outre des informations sur la composition des aliments, ce projet examine également les caractéristiques ethnobotaniques, économiques et socioculturelles des plantes. Cette approche holistique visant à évaluer le potentiel des espèces clés sous-utilisées pour la nutrition produira cinq résultats de recherche pour: i) les caractéristiques ethnobotaniques et agronomiques, ii) les caractéristiques nutritionnelles, iii) les caractéristiques économiques et socioculturelles de 10 espèces de plantes comestibles sous-utilisées dans la région d'Atacora (nord du Bénin), et (v) la promotion de ces espèces pour améliorer la nutrition de la population locale. Cette étude sera conduite par le bureau de l'Afrique de l'Ouest de Bioversity International sis au Bénin en collaboration avec le GIZ, l'Institut de Recherche et de Développement (IRD), la Faculté des Sciences Agronomiques de l'Université d'Abomey-Calavi (FSA/UAC), l'Université de Göttingen (Allemagne) et l'Université de Hohenheim (Allemagne).

Des données seront collectées auprès des personnes vivant dans des villages de différentes communes du département de l'Atacora, aussi bien des hommes que des femmes, des jeunes que des adultes et des personnes âgées ainsi que des personnes et structures intervenant dans à l'échelle locale dans les domaines de l'alimentation, de la nutrition et de la santé.

Objectifs de l'étude

L'objectif global du projet est de sensibiliser davantage les consommateurs sur le potentiel nutritionnel des espèces végétales comestibles sous-utilisées et à les motiver à intégrer ces espèces dans leur régime alimentaire. Cela comprend plusieurs objectifs de recherche dont les plus importants sont:

- **Identifier 11 espèces de plante comestibles à haut potentiel nutritionnel mais sous-utilisées ;**
- **Déterminer les caractéristiques ethnobotaniques, agronomiques, socioculturelles et économiques des espèces ;**
- **Evaluer la valeur nutritionnelle des 11 espèces** à travers des analyses de laboratoire **(**contenu en nutriments suivants : fer, zinc, calcium, magnésium, iode, sodium, vitamine A, vitamine C, protéines, eau, lipides, glucides, sucres réducteurs)

Ces informations permettront d'élaborer des recettes à haute valeur nutritionnelle à partir de plantes sous-utilisées. Ces recettes seront compilées dans un livret de recettes qui sera mis à disposition des centres de récupération nutritionnelle, des institutions qui interviennent à l'échelle locale dans les domaines de l'Alimentation, de la nutrition et de la santé, des relais communautaires et des groupements de femmes pour une meilleure alimentation de la population en général et celles des groupes vulnérables (les enfants et les femmes) en particulier.

Avantages et risques liés à l'étude

En participant à cette étude, vous contribuerez à faire progresser l'état des connaissances sur les ressources alimentaires disponibles dans votre localité et les pistes de leur valorisation. Il n'y pas de risque spécifique lié à votre participation outre le fait que nous prendrons une partie de votre temps pour les différents entretiens. Dans le cas des entretiens individuels, nous pourrions échanger avec vous au lieu et au moment que vous souhaiteriez. Vous êtes libres de nous interrompre à tout moment.

Compensation

Il n'est pas prévu de compensation financière pour la participation à cette étude. Cependant, quand on demandera à des participants de se déplacer dans le cas de Discussions de Groupes par exemple, on leur offrira une collation (aliments, etc.) ou un cadeau.

Noms des chercheurs au Bénin

Prof Waliou Amoussa Hounkpatin: Enseignant-Chercheur à la Faculté des Sciences Agronomiques de l'Université d'Abomey Calavi (FSA/UAC)

Prof Assogbadjo Achille Ephrem: Enseignant-Chercheur à la Faculté des Sciences Agronomiques de l'Université d'Abomey Calavi (FSA/UAC)

Fifali Sam Ulrich Bodjrenou: Doctorant (FSA/UAC) et chercheur avec Bioversity International

Personnes ressources

N'hésitez pas à poser des questions à tout moment pendant l'étude. Si vous avez un problème ou d'autres questions à propos de l'étude ou de vos droits en tant que participants, veuillez communiquer avec Prof Waliou Amoussa (FSA/UAC; tel : xxx) et Prof Assogbadjo Achille Ephrem (FSA/UAC; tel : xxx). Vous pouvez également contacter le Conseil National d'Ethique pour la Recherche en Santé (CNERS) en appelant le 64601201.

Confidentialité des dossiers

Tous les renseignements recueillis pour la présente étude sont confidentiels (secrets). Pour ce faire, ces renseignements seront codés; le numéro de code qui vous sera attribué sera utilisé pour toutes les analyses et traitements ultérieurs des données. Aucune information pouvant vous identifier ne sera alors dévoilée. Cependant, à des fins de contrôle du projet de recherche, votre dossier pourra être consulté par une personne mandatée par le Comité National d'Éthique de la Recherche en Santé (CNERS) du Bénin. Les données recueillies lors de cette étude seront conservées dans un classeur fermé à clé et dans des fichiers informatiques avec mot de passe pour une durée maximale de 5 ans, dans les locaux de Bioversity Benin.

Liberté de participation

La participation aux activités de l'étude se fait sur une base libre et volontaire pour chaque individu. Vous êtes donc libre de participer ou de ne pas participer à la présente étude. Si vous décidez d'y participer, vous aurez toujours le droit de vous retirer à tout moment sans justification, sans représailles, ni conséquences négatives pour vous et votre famille sur les prestations socio-sanitaires auxquelles vous avez habituellement droit.

Si vous le voulez, vous pouvez nous donner en même temps votre accord pour participer à l'étude. Nous pouvons également vous laisser le temps de réfléchir avant de nous dire votre

décision. Si c'est le cas nous pouvons revenir au cours de la journée à un moment que vous nous direz ou demain.

Engagement des chercheurs

Les chercheurs s'engagent à mener l'étude dans le respect de la dignité humaine et à respecter l'ensemble des dispositions énoncées dans la présente note d'informations, notamment, la liberté de participation, la confidentialité des informations recueillies, la dissémination des résultats aux participants et le soutien aux participants pour la prise en charge des enfants dépistés pour malnutrition aigüe sévère. Les chercheurs s'engagent également à travailler conjointement avec la communauté pour la mise en œuvre des stratégies de communication visant à promouvoir les bonnes pratiques d'alimentation de complément et de soins administrés aux nourrissons et jeunes enfants.

A la fin de l'étude, une copie des résultats sera remise à chacune des structures ci-après » :

- Comité National d'Éthique pour la Recherche en Santé (CNERS);
- Direction de la Recherche et de la formation (DRF);
- Services de Gestion du Système d'Information (SGSI);
- Conseil National de l'Alimentation et la Nutrition (CAN);
- Les communes de Atacora.

FORMULAIRE DE CONSENTEMENNT LIBRE ET ECLAIRE

Code du ménage: /_____/

Commune : _ Arrondissement : _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Village : _ Hameau : _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Famille : _ Ménage _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

Nom du Signataire (répondant) _

Age (années) : _ _ _ _ Sexe : Homme /_____/ Femme /_____/

Bioversity International, l'Université d'Abomey-Calavi (Bénin), GIZ, IRD, l'Université de Göttingen et l'Université de Hohenheim effectuent une recherche sur le thème **«Accroitre la demande des consommateurs et l'utilisation d'espèces de plantes nutritives sous-utilisées dans l'alimentation des populations du Nord-Bénin**».

Vous/votre ménage a été choisi avec l'aide des autorités locales et des agents de santé communautaires locaux pour participer à cette étude. Nous vous demandons de participer à cette étude à la lumière des détails que nous vous avons fournis dans la note d'informations qui vous a été remise. Votre participation est totalement volontaire. Vous êtes libre de changer d'avis à tout moment si vous ne souhaitez plus participer à l'étude.

Consentement du répondant

Affirmations	**Oui**	**Non**
J'ai lu (ou j'ai fait lire)/ on m'a lu/ et j'ai compris les informations sur le but de l'étude (Note d'information)		
L'équipe de recherche m'a expliqué et j'ai compris mes droits par rapport à cette étude : participation volontaire, liberté de choix du lieu de collecte de données, confidentialité des données recueillies etc. (Note d'information)		
L'équipe de recherche m'a expliqué et j'ai compris les inconvénients et les avantages liés à ma participation à cette étude		
L'équipe de recherche m'a expliqué et j'ai compris que les dossiers de recherche pourraient être inspectés par le comité d'éthique du Bénin pour s'assurer du bon déroulement de l'étude		
J'ai compris que les données collectées pourront faire l'objet de publication tout en respectant la confidentialité des participants		
J'ai eu l'occasion de poser toutes les questions aux membres de l'équipe de recherche. Les réponses m'ont été fournies dans un langage que je comprends.		
Il m'a été clairement expliqué et j'ai compris que mon consentement ne décharge pas les organisateurs de la recherche de leur responsabilité et je conserve tous mes droits tels que garantis par la loi		
Je consens de façon libre et éclairée à participer à cette enquête.		

Nom du répondant	Signature ou empreinte digitale	Date

Engagement des chercheurs

En signant ce formulaire, les chercheurs s'engagent à conduire l'étude dans le respect de la dignité humaine et à respecter l'ensemble des dispositions énoncées dans le présent formulaire et dans les notes d'informations.

Nom du l'agent de recherche	Signature	Date

13.3. Sociodemographic characteristics of the research sample

Table 19 Sociodemographic characteristics of professional experts

Number of interview	Date	Gender	Age (years)	Socio-linguistic group	Profession	Highest education level
1	26.10.2019	Male	34	Yora	Agricultural advisor	Bachelors
2	28.10.2019	Male	28	Waama	Agricultural advisor	Bachelors
3	30.10.2019	Male	29	Waama	Nutritional advisor	Bachelors
4	30.10.2019	Male	24	Waama	Agricultural advisor	Bachelors
5	31.10.2019	Male	29	Berba	Nutritional advisor	12th grade
6	31.10.2019	Male	38	Fon	Social worker	Masters
7	01.11.2019	Male	39	Dendi	Agricultural advisor	Bachelors
8	01.11.2019	Male	38	Gourmantché	Program coordinator nutrition	Bachelors
9	01.11.2019	Male	38	Natimba	Program coordinator nutrition	Masters
10	01.11.2019	Male	37	Berba	Farm director	Bachelors
11	08.11.2019	Male	36	Mahi	Nutritonal advisor	Masters
12	12.11.2019	Female	26	Otamari	Nutritonal advisor	9th grade
13	12.11.2019	Female	22	Otamari	Nutritonal advisor	10th grade
14	12.11.2019	Female	52	Dendi	Nutritonal advisor	9th grade
15	12.11.2019	Female	30	Adja	Coordinator of nutritional therapy center	12th grade
16	14.11.2019	Female	39	Fon	Technical advisor nutrition	Masters
17	22.11.2019	Female	52	German	Technical advisor nutrition	12th grade
18	23.11.2019	Male	27	Berba	Doctoral student in nutrition	Masters

Table 20 Sociodemographic characteristics of local experts

Number of interview	Date	Commune	Village	Gender	Age (years)	Socio-linguistic group	Profession	Highest education level	Religion
1	24.10.2019	Toucountouna	Tectibayaou	Male	63	Waama	Farmer	None	Christianity
2	24.10.2019	Toucountouna	Tectibayaou	Male	52	Waama	Farmer	1st grade	Christianity
3	24.10.2019	Toucountouna	Tectibayaou	Male	55	Waama	Farmer	3rd grade	Christianity
4	24.10.2019	Toucountouna	Tectibayaou	Male	58	Waama	Farmer	5th grade	Christianity
5	25.10.2019	Tanguiéta	Douani	Male	70	Natimba	Farmer	None	Traditional religions
6	25.10.2019	Tanguiéta	Douani	Female	70	Natimba	Farmer	None	Christianity
7	25.10.2019	Tanguiéta	Douani	Male	70	Natimba	Farmer	None	Christianity
8	25.10.2019	Tanguiéta	Douani	Female	51	Natimba	Farmer	None	Christianity
9	25.10.2019	Tanguiéta	Kosso	Male	51	Waama	Farmer	5th grade	None
10	25.10.2019	Tanguiéta	Kosso	Female	65	Waama	Farmer	None	Christianity
11	25.10.2019	Tanguiéta	Kosso	Male	54	Waama	Farmer	None	Christianity
12	25.10.2019	Tanguiéta	Kosso	Male	56	Waama	Farmer	2nd grade	Traditional religions
13	28.10.2019	Toucountouna	Wabou	Male	52	Waama	Farmer	None	Christianity
14	28.10.2019	Toucountouna	Wabou	Female	71	Waama	Farmer	2nd grade	None
15	28.10.2019	Toucountouna	Wabou	Male	50	Waama	Farmer	3rd grade	Christianity
16	28.10.2019	Toucountouna	Wabou	Male	53	Waama	Farmer	4rd grade	Christianity
17	29.10.2019	Natitingou	Kampouya	Female	60	Waama	Farmer	None	Christianity
18	29.10.2019	Natitingou	Kampouya	Male	63	Waama	Farmer	Kindergarter	Christianity
19	29.10.2019	Natitingou	Kampouya	Male	55	Waama	Farmer	None	Traditional religions
20	29.10.2019	Natitingou	Kampouya	Female	50	Waama	Farmer	None	Traditional religions
21	30.10.2019	Natitingou	Koukoibrigrou	Male	50	Otamari	Farmer	Kindergarter	Traditional religions
22	30.10.2019	Natitingou	Koukoibrigrou	Female	70	Otamari	Farmer	1st grade	Christianity
23	30.10.2019	Natitingou	Koukoibrigrou	Male	68	Otamari	Farmer	None	Traditional religions
24	30.10.2019	Natitingou	Koukoibrigrou	Male	58	Otamari	Farmer	None	Traditional religions

Table 21 Sociodemographic characteristics of focus group participants

Number of focus group	Number of focus group participant	Date	Commune	Village	Gender	Age (years)	Socio-linguistic group	Religion	Profession	Highest education level
1	1	05.11.2019	Natitingou	Kampouya	Male	50	Waama	Traditional religions	Farmer	None
1	2	05.11.2019	Natitingou	Kampouya	Male	72	Waama	Traditional religions	Farmer	None
1	3	05.11.2019	Natitingou	Kampouya	Male	32	Waama	Traditional religions	Farmer	7th grade
1	4	05.11.2019	Natitingou	Kampouya	Male	55	Waama	Traditional religions	Farmer	None
1	5	05.11.2019	Natitingou	Kampouya	Male	45	Waama	Traditional religions	Farmer	None
1	6	05.11.2019	Natitingou	Kampouya	Male	35	Waama	Traditional religions	Farmer	None
2	7	09.11.2019	Natitingou	Kampouya	Female	46	Waama	Traditional religions	Farmer	None
2	8	09.11.2019	Natitingou	Kampouya	Female	35	Waama	Traditional religions	Farmer	2nd grade
2	9	09.11.2019	Natitingou	Kampouya	Female	30	Waama	Christianity	Farmer	None
2	10	09.11.2019	Natitingou	Kampouya	Female	28	Waama	Christianity	Farmer	3rd grade
2	11	09.11.2019	Natitingou	Kampouya	Female	27	Waama	Christianity	Farmer	None
2	12	09.11.2019	Natitingou	Kampouya	Female	18	Waama	Christianity	Farmer	None
3	13	11.11.2019	Toucoutouna	Tectibayaou	Male	21	Waama	Islam	Farmer	9th grade
3	14	11.11.2019	Toucoutouna	Tectibayaou	Male	41	Waama	Christianity	Farmer	5th grade
3	15	11.11.2019	Toucoutouna	Tectibayaou	Male	28	Waama	Islam	Farmer	12th grade
3	16	11.11.2019	Toucoutouna	Tectibayaou	Male	24	Waama	Christianity	Farmer	12th grade
3	17	11.11.2019	Toucoutouna	Tectibayaou	Male	35	Waama	Traditional religions	Farmer	8th grade
3	18	11.11.2019	Toucoutouna	Tectibayaou	Male	51	Waama	Christianity	Farmer	5th grade
4	19	11.11.2019	Toucoutouna	Tectibayaou	Female	26	Waama	Traditional religions	Farmer	6th grade
4	20	11.11.2019	Toucoutouna	Tectibayaou	Female	45	Waama	Christianity	Farmer	Kindergarten
4	21	11.11.2019	Toucoutouna	Tectibayaou	Female	40	Waama	Christianity	Farmer	None
4	22	11.11.2019	Toucoutouna	Tectibayaou	Female	60	Waama	Christianity	Farmer	None
4	23	11.11.2019	Toucoutouna	Tectibayaou	Female	40	Waama	Christianity	Farmer	1st grade
4	24	11.11.2019	Toucoutouna	Tectibayaou	Female	30	Waama	Christianity	Farmer	2nd grade
5	25	13.11.2019	Toucoutouna	Wabou	Female	70	Waama	Christianity	Farmer	5th grade
5	26	13.11.2019	Toucoutouna	Wabou	Female	50	Waama	Traditional religions	Farmer	None
5	27	13.11.2019	Toucoutouna	Wabou	Female	68	Waama	Traditional religions	Farmer	None
5	28	13.11.2019	Toucoutouna	Wabou	Female	48	Waama	Traditional religions	Farmer	None
5	29	13.11.2019	Toucoutouna	Wabou	Female	63	Waama	Traditional religions	Farmer	None
5	30	13.11.2019	Toucoutouna	Wabou	Female	40	Waama	Christianity	Farmer	None
6	31	13.11.2019	Tanguieta	Wabou	Male	25	Waama	Traditional religions	Farmer	4th grade
6	32	13.11.2019	Tanguieta	Wabou	Male	42	Waama	Traditional religions	Farmer	None
6	33	13.11.2019	Tanguieta	Wabou	Male	49	Waama	Traditional religions	Farmer	2nd grade
6	34	13.11.2019	Tanguieta	Wabou	Male	20	Waama	Christianity	Farmer	5th grade
6	35	13.11.2019	Tanguieta	Wabou	Male	19	Waama	Christianity	Farmer	3rd grade
6	36	13.11.2019	Tanguieta	Wabou	Male	50	Waama	Traditional religions	Farmer	None
7	37	15.11.2019	Natitingou	Koukobirgou	Female	33	Otamari	Christianity	Farmer	2nd grade
7	38	15.11.2019	Natitingou	Koukobirgou	Female	70	Otamari	Christianity	Farmer	2nd grade
7	39	15.11.2019	Natitingou	Koukobirgou	Female	45	Otamari	Christianity	Farmer	None
7	40	15.11.2019	Natitingou	Koukobirgou	Female	35	Otamari	Christianity	Farmer	None
7	41	15.11.2019	Natitingou	Koukobirgou	Female	19	Otamari	Traditional religions	Farmer	2nd grade
7	42	15.11.2019	Natitingou	Koukobirgou	Female	40	Otamari	Traditional religions	Farmer	3rd grade
8	43	15.11.2019	Natitingou	Koukobirgou	Male	25	Otamari	Christianity	Farmer	12th grade
8	44	15.11.2019	Natitingou	Koukobirgou	Male	60	Otamari	Traditional religions	Farmer	3rd grade
8	45	15.11.2019	Natitingou	Koukobirgou	Male	40	Otamari	Traditional religions	Farmer	2nd grade
8	46	15.11.2019	Natitingou	Koukobirgou	Male	20	Otamari	Christianity	Farmer	7th grade
8	47	15.11.2019	Natitingou	Koukobirgou	Male	63	Otamari	Christianity	Farmer	None
8	48	15.11.2019	Natitingou	Koukobirgou	Male	20	Otamari	Christianity	Farmer	2nd grade
9	49	18.11.2019	Tanguieta	Kosso	Female	35	Waama	Traditional religions	Farmer	None
9	50	18.11.2019	Tanguieta	Kosso	Female	64	Waama	Traditional religions	Farmer	None
9	51	18.11.2019	Tanguieta	Kosso	Female	25	Waama	Traditional religions	Farmer	5th grade
9	52	18.11.2019	Tanguieta	Kosso	Female	30	Waama	Traditional religions	Farmer	None
9	53	18.11.2019	Tanguieta	Kosso	Female	50	Waama	Traditional religions	Farmer	None
9	54	18.11.2019	Tanguieta	Kosso	Female	36	Waama	Traditional religions	Farmer	5th grade
10	55	18.11.2019	Tanguieta	Kosso	Male	22	Waama	Traditional religions	Farmer	8th grade
10	56	18.11.2019	Tanguieta	Kosso	Male	27	Waama	Traditional religions	Farmer	None
10	57	18.11.2019	Tanguieta	Kosso	Male	32	Waama	Traditional religions	Farmer	None
10	58	18.11.2019	Tanguieta	Kosso	Male	53	Waama	Traditional religions	Farmer	None
10	59	18.11.2019	Tanguieta	Kosso	Male	60	Waama	Traditional religions	Farmer	None
10	60	18.11.2019	Tanguieta	Kosso	Male	49	Waama	Traditional religions	Farmer	5th grade
11	61	21.11.2019	Tanguieta	Douani	Female	53	Natimba	Traditional religions	Farmer	None
11	62	21.11.2019	Tanguieta	Douani	Female	80	Fulani	Islam	Farmer	None
11	63	21.11.2019	Tanguieta	Douani	Female	32	Natimba	Christianity	Farmer	6th grade
11	64	21.11.2019	Tanguieta	Douani	Female	40	Natimba	Christianity	Farmer	2nd grade
11	65	21.11.2019	Tanguieta	Douani	Female	24	Berba	Christianity	Farmer	8th grade
11	66	21.11.2019	Tanguieta	Douani	Female	24	Natimba	Traditional religions	Farmer	5th grade
12	67	21.11.2019	Tanguieta	Douani	Male	32	Natimba	Christianity	Farmer	5th grade
12	68	21.11.2019	Tanguieta	Douani	Male	33	Natimba	Islam	Farmer	5th grade
12	69	21.11.2019	Tanguieta	Douani	Male	64	Natimba	Islam	Farmer	None
12	70	21.11.2019	Tanguieta	Douani	Male	64	Natimba	Christianity	Farmer	None
12	71	21.11.2019	Tanguieta	Douani	Male	42	Natimba	Islam	Farmer	5th grade
12	72	21.11.2019	Tanguieta	Douani	Male	25	Berba	Christianity	Farmer	12th grade

13.4. Interview guidelines

13.4.1. Interview guideline for semi-structured interviews with local experts

1.Toutes les espèces
Parmi ces espèces (photos), pouvez-vous me dire lesquelles vous connaissez?
Lesquelles de ces onze espèces avez-vous déjà mangé? *(Photos)*
Espèces consommées 2.1
Lesquelles des espèces préférez-vous le plus ou le moins pour consommer?

- Pouvez-vous classer les espèces en termes de vos préférences pour les manger? *(Photos)*
- Quelles sont les raisons pour lesquelles vous préférez ces espèces plus ou moins?

Lesquelles de ces espèces consommez-vous souvent, lesquelles seulement dans certaines occasions?

- Pouvez-vous classer les espèces en termes de votre fréquence de les manger? (Photos)
- Chez lesquelles des espèces la fréquence de consommation varie pendant l'année? Comment est la variation?
- Que pensez-vous sont les raisons pour lesquelles vous consommez certaines espèces plus ou moins souvent?
- Il y a des espèces qui vous avez consommez plus souvent quand vous étiez jeune?
- Lesquelles des espèces aimeriez-vous consommez plus?

Espèces non-consommées 2.2
Il y a des espèces que vous utilisez pour d'autres usages que la consommation?

- Lesquelles et pour quelles utilisations?

Avez-vous une idée, pourquoi vous n'avez jamais consommée ces espèces?
Espèces inconnus, explication de l'utilité des espèces comme aliment

2.1 Espèces consommées *(répéter pour les espèces sélectionnes)*
Comment appelez-vous cette espèce?
Quelle partie de l'espèce X consommez-vous habituellement?
Vous souvenez-vous quand vous avez mangé l'espèce X pour la première fois?
Comment votre consommation de l'espèce X a-t-elle évolué depuis lors?

- Dans quelles saisons et à quelle fréquence consommez-vous l'espèce aujourd'hui et dans le passé?

Selon vous qu'est-ce qui a influé votre consommation de l'espèce X?
Accessibilité, accès financier, convenance
Est-ce que la disponibilité de l'espèce X dans votre l'environnement pourrait-elle avoir une influence sur votre consommation (changée)?

- Comment est-ce que vous avez acquis l'espèce X dans le passé et aujourd'hui? (cultivé, récolté, acheté, échangé etc.)
- Comment la disponibilité géographique (distribution)/temporelle (saisons) a-t-elle changé?
- *Si l'espèce est achetée,* comment l'accès financier à l'espèce (prix) a-t-il changé?

Est-ce que le temps et les efforts à faire avant que l'espèce X ne soit prête à manger pourrait-elle avoir une influence sur votre consommation (changée)?

- Comment percevez-vous le temps et effort de récolte, d'achat, de transformation et de préparation le passé et aujourd'hui?
- Existe-t-il des propriétés végétales spécifiques qui rendent la consommation de l'espèce plus facile ou plus difficile? (Composants physiques tels que les épines, écorce durs, taille des fruits etc.et non-comestibles, toxique etc.)

Significations (organisation, classification socioculturelle)
Est-ce que l'organisation de récolte/achat, de transformation et de préparation des aliments de l'espèce X pourrait-elle avoir une influence sur votre consommation (changée)?

- Qui d'habitude récolte, achète l'espèce? Qui le prépare d'habitude? (Rôles sociales) Comment c'était dans le passé?
- Qui est autorisé à récolter, acheter, préparer et manger l'espèce X? (Propriété des arbres et des terres, règles et tabous, etc.) Comment c'était dans le passé?
- Qui décide habituellement de ce que l'on mange? (Prise de décision) Comment c'était dans le passé?
- Qui devrait manger ou ne pas manger l'espèce X? Comment c'était dans le passé?

Est-ce que votre opinion sur la consommation de l'espèce X pourrait-elle avoir une influence sur votre consommation (changée)?

- Quels sont les avantages et désavantages de consommer l'espèce X? Est-ce que votre opinion a changé par rapport au passé?
- Est-ce que l'espèce fait partie des aliments que vous offririez aux visiteurs ou que vous cuisineriez pour un évènement social? Comment c'était dans le passé?
- Est-ce que vous pensez que l'espèce fait partie de votre culture alimentaire? Est-ce que votre opinion a changé par rapport au passé?

Connaissances, savoir-faire, propriétés sensorielles

Est-ce que la façon dont vous vous occupez de l'espèce X pourrait-elle avoir une influence sur votre consommation (changée)?

- Est-ce que l'espèce est protégée, sa production intensifiée etc.?
- De qui avez-vous appris à gérer l'espèce X?
- Comment vos connaissances sur la gestion de l'espèce a-t-elle changé par rapport au passé?

Est-ce que les connaissances comment récolter, préparer, conserver l'espèce X pourraient-ils avoir une influence sur votre consommation (changée)?

- Comment l'espèce est-elle préparée avant consommation (consommée crue, cuite, frite, mélangée à d'autres aliments etc.)?
- De qui vous avez appris comment il faut acquérir, préparer, conserver etc. l'espèce?
- Est-ce que vos descendants savent comment acquérir, préparer, conserver l'espèce?

Est-ce que vos raisons pourquoi est-il important pour vous de consommer l'espèce X pourraient-ils avoir une influence sur la consommation (changée)?

- Quels sont les bénéfices de consommer l'espèce X?
- Comment ces raisons ont-changé par rapport au passé?

Est-ce que vos préférences de goût de l'espèce X pourraient-ils avoir une influence sur la sur la consommation (changée)?

- Que pensez-vous du goût de l'espèce?
- Comment votre perception de goût a changé par rapport au passé?

Résume

Est -ce que vos préférences ont-ils changés vers des alternatives à l'espèce X?

- Vers quelles alternatives et pourquoi?

Est-ce que d'autres utilisations de l'espèce X en plus de manger pourraient-ils avoir une influence sur votre consommation (changée)? *(Comme les médicaments, utilisés dans les cérémonies, etc.)*

- Sont des produits de de l'espèce commercialisées? Lesquelles?
- Que pensez-vous de l'utilisation la plus importante de l'espèce?
- Comment l'importance de ces usages a-t-elle changé?

D'après ce dont nous avons discuté, quelles sont les choses qui ont les plus influencés votre consommation de l'espèce X?
Comment voyez-vous le rôle de l'espèce X dans votre alimentation à l'avenir?
Avez-vous d'autres choses au sujet de l'espèce X que vous aimeriez partager avec moi?

2.2 Espèces jamais consommées *(répéter pour les espèces sélectionnées)*

Comment appelez-vous cette espèce?
Utilisez-vous l'espèce X à d'autres fins que la consommation alimentaire?

- Si oui, comment utilisez-vous le plus les espèces?

- Si non, l'espèce X est-elle disponible dans votre région?

Quelles sont les raisons pour lesquelles vous ne consommez pas l'espèce?

Les facteurs suivants pourraient-ils avoir une influence: …

Accessibilité, accès financier, convenance

- Disponibilité de l'espèce X
  - Disponibilité physique et temporelle de l'espèce
  - Prix de l'espèce
- Temps et efforts jusqu'à ce que l'espèce X soit prête à manger des
  - Collecter, récolter, préparer l'espèce
    - Propriétés physiques et chimiques de l'espèce qui rendent difficile la récolte, conservation, préparation, consommation

Organisation, classification socioculturelle

- L'organisation de la récolte, de la préparation et de la consommation de l'espèce X
  - Répartition du travail: qui fait quoi
  - Règles concernant qui et quand il est permis de récolter et de manger l'espèce (tabous)
  - Prise de décision dans les ménages pour consommer l'espèce
- L'opinion sur l'espèce X

Connaissances, savoir-faire, propriétés sensorielles

- Connaissances de la biologie, écologie de l'espèce X
  - Savoir comment cultiver, gérer l'espèce X, savoir ou récolter l'espèce
- Savoir pourquoi et comment utiliser l'espèce X
  - Savoir sur l'utilité de l'espèce pour la santé etc.
  - Savoir comment préparer, conserver etc. l'espèce
  - Transmission de savoir-faire
- Préférences de gout pour l'espèce X

Résumé

Y-a-t-il des alternatives de l'espèce X que vous préfériez?

- Lesquelles et pourquoi vous préférez cette alternative?

Est-ce que vous utilisez l'espèce pour d'autres choses que la consommation? (comme revenu, médicine, utilisation pour des cérémonies etc.)

- Quelle est l'utilisation de l'espèce la plus importante pour vous?
- L'importance de ces usages ont-ils change par rapport au passé?

Y a-t-il d'autres facteurs qui, selon vous, entravent la consommation de l'espèce X?

Seriez-vous intéressé à essayer l'espèce X pour la nourriture?

- Pourquoi (pas)?

Avez-vous d'autres choses à propos de l'espèce que vous aimeriez partager avec moi?

3. Conclusion pour toutes les espèces sélectionnées

Comment voyez-vous le rôle de ces espèces dans votre alimentation dans le futur?

- Qu'est-ce que rend les choses difficiles pour vous pour consommer ces espèces (plus fréquentes et - en plus grande quantité)?
- Qu'est-ce que rend les choses faciles pour vous pour consommer ces espèces (plus fréquentes et en plus grande quantité)? ?

Qu'est-ce que vous aiderait à augmenter la consommation de ces espèces?

- Qu'est-ce que vous pouvez faire pour consommer ces espèces (plus)?
- Comment vous voyez les rôles des agents qui sont active dans le domaine de l'agriculture, de la nutrition, et de la santé (comme ONG, les agents de vulgarisation gouvernementaux, les autres autorités, les membres influents de la communauté etc.)

Avez-vous autre chose que vous aimeriez partager?

4. Caractéristiques sociodémographiques

13.4.2. Interview guideline for semi-structured interviews with professional experts

1. Toutes les espèces

Quelle est la région couverte par votre travail?
Avec lesquelles des espèces vous/votre équipe a fait des expériences dans les communautés où vous travaillez?
Avez-vous une idée lesquelles de ces onze espèces sont consommées dans les communautés où vous travaillez? *(Photos)*

Espèces connues comme consommé 2.1

Lesquelles des espèces sont préfèrent pour la consommation dans les communautés?

- Pouvez-vous classer les espèces en termes des préférences d'être consommer? *(Photos)*
- Quelles sont les raisons pour lesquelles ces espèces sont préférées plus que d'autres?

Lesquelles des espèces sont plus souvent consommer que d'autres?

- Pouvez-vous classifier ces espèces en termes de ceux qui sont rarement, parfois ou souvent consommées dans les communautés ou vous travaillez?

Chez lesquelles des espèces la fréquence de consommation varie pendant l'année? Comment est la variation?
Quelles de ces espèces vous considérer comme sous-utilisée en termes de leur niveau de consommation?

- Lesquelles des espèces seraient les plus prometteuses pour leur promotion d'intégration dans l'alimentation des communautés?
- Pouvez-vous classer les espèces en fonction de leur potentiel en matière de consommation? Pourquoi?

Espèces connues comme non-consommé 2.2

Il y a des espèces qui sont utilisées pour d'autres usages que la consommation?

- Lesquelles et pour quelles utilisations?

Avez-vous une idée, quelles sont les raisons pour lesquelles ces espèces ne sont pas consommées?

- Selon vous, quels de ces espèces ont le plus du potentiel d'être réintégrer en l'alimentation? Pourquoi?

Espèces inconnues, explication de l'utilité des espèces comme aliment

2. Espèces sélectionnées

2.1 Espèces connues comme étant consommée *(répété d'abord pour chaque espèce consommée)*

Comment appelez-vous cette espèce?
Quelle est l'expérience de votre organisation/ministère/institution/équipe en ce qui concerne l'espèce X?
Quelle partie de l'espèce X est habituellement consommée dans les communautés ou vous travaillez?
Avez-vous perçu un changement dans le niveau de consommation de l'espèce X par rapport au passé dans les communautés où vous travaillez?
Selon vous, qu'est-ce qui a influencé le fait que l'espèce X soit plus ou moins consommée que dans le passé?

Accessibilité, accès financier, convenance

Est-ce qu'un changement de la disponibilité de l'espèce X dans l'environnement pourrait-il avoir influencé la consommation (changée)?? Comment la disponibilité a-t-elle changé par rapport au passé*?*

- *Comment est-ce que l'espèce est acquis dans le passé et aujourd'hui (Cultivé, récolté, acheté, échangé etc.)?*
- *C*omment la disponibilité géographique (distribution)/temporelle (saisons) a-t-elle changé?
- *C*omment l'accès financier à l'espèce (prix) a-t-il changé?

Est-ce qu'un changement dans la perception du temps et des efforts nécessaires pour que l'espèce X soit prête à consommer pourrait-il avoir influencé la consommation (changée)?

- Selon vous, comment le temps et effort de récolte, d'achat, de transformation et de préparation est perçue dans les communautés dans le passé et aujourd'hui?
- Existe-t-il des propriétés végétales spécifiques qui rendent la consommation de l'espèce plus facile ou plus difficile? *(Composants physiques tels que les épines, écorce durs, taille des fruits etc.et/ou non-comestibles etc.)*

Organisation, classification socioculturelle

Est-ce que l'organisation de récolte/achat, de transformation et de préparation des aliments de l'espèce X a-t-elle changé et pourrait-elle avoir influencé la consommation (changée)?

- Qui est autorisé à récolter, acheter, préparer et manger l'espèce X? (Propriété des arbres et des terres, règles et tabous, etc.) Comment c'était dans le passé?
- Qui d'habitude récolte, achète l'espèce au sein des ménages? Qui le prépare d'habitude? (Rôles sociales) Comment c'était dans le passé?
- Qui décide habituellement de ce que l'on mange dans les ménages? (Prise de décision) Comment c'était dans le passé?

Est-ce que les opinions dans les communautés sur la consommation de l'espèce X a-t-elle changé et pourrait-elle avoir influencé la consommation (changée)?

- Quels sont les avantages et désavantages attribués à l'espèce X? Comment c'était dans le passé?
- Comment la consommation de l'aliment est-elle considérée socialement? Comment c'était dans le passé?
- Est-ce que vous diriez que l'espèce fait partie de la culture alimentaire locale? Comment c'était dans le passé?

Connaissances, savoir-faire, propriétés sensorielles

Est-ce que les connaissances sur l'espèce X en termes sa biologie et de gestion ont-ils changées et pourraient-ils avoir influencé la consommation (changée)?

- Est-ce que l'espèce est protégée ou sa production intensifiée? Comment c'était dans le passé?
- Qui possède beaucoup de connaissances sur l'espèce? Comment c'était dans le passé?

Est-ce que les connaissances comment récolter, préparer, conserver l'espèce X ont-ils changés et pourraient-ils avoir influencé la consommation (changée)?

- Comment l'espèce est-elle préparée avant consommation (consommée crue, cuite, frite, mélangée à d'autres aliments etc.)?
- De qui vous avez appris comment il faut acquérir, préparer, transformer, conserver etc. l'espèce X?
- Est-ce que ces savoir-faire sont transmis aux générations plus jeunes?

Est-ce que la sensibilisation à l'utilité de la consommation de l'espèce X a-t-elle change et pourrait-elle avoir influencé la consommation (changée)?

- Quels sont les bénéfices de consommer l'espèce X? Est-ce que ces raisons ont changé par rapport au passé?

Est-ce que les préférences de goût pour l'espèce X ont-ils change et pourraient-ils avoir influencé la consommation (changée)?

- Comment le goût de l'espèce est-il perçu? Comment c'était dans le passé?

Résumé

Avez-vous remarqué un changement vers des alternatives à l'espèce X qui sont préférées?

- Selon vous pourquoi cette alternative est préférée?

Est-ce que les utilisations de l'espèce X ont-ils changé et pourraient-ils avoir influencé la consommation (changée)? (Autres utilisations comme les médicaments, utilisés dans les cérémonies, etc.)?

- Est-ce que la nourriture de l'espèce est aussi vendu? Comment c'était dans le passé?
- Que pensez-vous de l'utilisation la plus importante de l'espèce? L'importance des usages a-t-elle changé?

Selon vous quels sont les facteurs qui ont le plus influencé (le changement) de consommation de l'espèce X?
Comment voyez-vous le rôle de l'espèce X dans le régime alimentaire de vos communautés à l'avenir?
- Quel potentiel voyez-vous en l'espèce dans le régime alimentaire?

Avez-vous d'autres choses au sujet de l'espèce X que vous aimeriez partager avec moi?

2.2 Espèces connues comme non-consommées *(répété pour chaque espèce non-consommée)*
Comment appelez-vous cette espèce?
Savez-vous si l'espèce est utilisée à d'autres fins que l'alimentation?
- *Si oui, comment l'espèce est-elle principalement utilisée?*
- *Si non, l'espèce est-elle disponible dans votre région?*

Savez-vous quelles pourraient être les raisons pour lesquelles l'espèce n'est pas utilisée pour se nourrir?
Les facteurs suivants pourraient-ils avoir également une influence: …
Accessibilité, accès financier, convenance
- Disponibilité de l'espèce X
  - Disponibilité physique et temporelle de l'espèce
  - Prix de l'espèce
- Temps et efforts jusqu'à ce que l'espèce X soit prête à manger des
  - Collecter, récolter, préparer l'espèce
  - Propriétés physiques et chimiques de l'espèce qui rendent difficile la récolte, conservation, préparation, consommation

Organisation, classification socioculturelle
- L'organisation de la récolte, de la préparation et de la consommation de l'espèce X
  - Répartition du travail: qui fait quoi
  - Règles concernant qui et quand il est permis de récolter et de manger l'espèce (tabous)
  - Prise de décision dans les ménages pour consommer l'espèce
- L'opinion sur l'espèce X
  - Comme démodée, consommatrice de temps, faible statut social, pas part des habitudes alimentaires culturelles
  - D'autres utilisations de l'espèce plus importantes comme revenu, médicine, utilisation pour des cérémonies etc.

Connaissances, savoir-faire, propriétés sensorielles
- Connaissances de la biologie, écologie de l'espèce X
  - Savoir comment cultiver, gérer l'espèce X, savoir ou récolter l'espèce
- Savoir pourquoi et comment utiliser l'espèce X
  - Savoir sur l'utilité de l'espèce pour la santé etc.
  - Savoir comment préparer, conserver etc. l'espèce
  - Transmission de savoir-faire
- Préférences de gout pour l'espèce X

Résumé
Est-ce que vous connaissez des alternatives à la consommation de l'espèce X qui sont préférées?
- Pourquoi cette alternative est préférée?

Est-ce que l'espèce est utilisée pour d'autres choses que la consommation? (comme revenu, médicine, utilisation pour des cérémonies etc.)
- Quelle est l'utilisation de l'espèce la plus importante?
- L'importance de ces usages ont-ils change par rapport au passé?

Est-ce que d'autres facteurs vous viennent à l'esprit qui empêchent la consommation de l'espèce X?

Comment voyez-vous le rôle de l'espèce X dans le régime alimentaire de vos communautés à l'avenir?

- Quel potentiel voyez-vous en l'espèce dans le régime alimentaire?

Avez-vous d'autres choses au sujet de l'espèce X que vous aimeriez partager avec moi?

3. Conclusion sur toutes les espèces sélectionnées

Quelles possibilités existent-ils après-vous pour augmenter la consommation de ces espèces au sein des communautés?

- Selon vous, quelles sont les potentiels pour promouvoir la consommation de ces espèces dans l'alimentations des membres de communautés?
- Selon vous, quels sont les obstacles pour promouvoir la consommation de ces espèces dans l'alimentations des membres de communautés?
- Comment vous voyez le rôle de votre institution dans la promotion de la consommation de ces espèces?
- Comment vous voyez les rôles d'autres agents qui sont active dans le domaine de la nutrition et l'agriculture *(comme ONG, les agents de vulgarisation gouvernementaux, les autres autorités, les membres influents de la communauté etc.)*
- Comment vous voyez le rôle des membres de la communauté eux-mêmes?

Avez-vous autre chose que vous aimeriez partager?

4. Caractéristiques sociodémographiques

13.4.3. Interview guideline for focus group discussions

1. Présentation de toutes les participantes

Au début, nous aimerions mieux vous connaitre. Vous connaissez déjà nos noms, mais nous souhaitons aussi connaitre vos noms. Pour cette raison, nous avons préparé un petit jeu.
S'il vous plaît, essayons de nous mettre en cercle. Je vais lancer la balle que je tiens à la main à l'un de vous. La personne qui attrape la balle doit dire son nom et son prénom ainsi que deux aliments qu'elle aime manger. Cette personne à son tour lancera la balle à une autre personne de son choix et ainsi de suite.

2. Cconsommation des espèces *(répéter pour toutes les espèces séparément)*

2.1 Connaissez-vous cette espèce de plante? Est-ce qu'il y a des personnes qui ne la connaissent pas?
2.2 Que savez-vous de l'espèce X? Quelles sont ses utilisations?
2.3 Quiconque parmi vous a déjà consommée l'espèce X?

- Aux participants qui consomment l'espèce X:
    - Pouvez-vous nous dire quelles parties et comment vous consommez l'espèce X?
    - Pouvez-vous nous dire quand et a quelle fréquence vous consommez l'espèce X?
    - Est-ce que votre consommation de l'espèce X a changé au fil des dernières années?
    - Pouvez-vous nous expliquer pourquoi vous consommez l'espèce X?
- Aux participants qui ne sont pas des consommateurs :
    - Selon vous, quelles sont les raisons pour lesquelles vous ne consommez pas l'espèce X?

2.4 Vous avez déjà mentionné quelques raisons pour lesquelles vous consommez ou pas l'espèce X et on aimerait encore mieux comprendre ce qui influence votre consommation.

Est-ce que (facteur Y) empêche ou favorise votre consommation de l'espèce X? Comment et pourquoi ça influence positivement ou négativement?

Facteurs	**Explication**	**Exemples d'augmentation de la consommation**	**Exemples de la diminution de la consommation**
Disponibilité physique de l'espèce X	L'espèce est disponible en grand nombre ou pas du tout disponible du milieu	L'espèce est cultivée dans le milieu Il y a des arbres qui étaient déjà toujours là	L'espèce est abattue pour avoir du bois de feux C'est une espèce sauvage qui ne pousse pas au village
Disponibilité temporelle de l'espèce X	L'espèce est disponible toute l'année ou seulement dans certaines périodes	Pendant toute l'année l'espèce est disponible pour en manger On produit tellement beaucoup ou on conserve l'espèce que ça soit disponible toute l'année	L'espèce est seulement disponible au début des premières pluies On n'a pas de stockage ou des possibilités de conserver l'espèce
Accessibilité financière de l'espèce X	Moyens financiers pour acheter des parties de l'espèce X ou pas	Il y a toujours de l'argent disponible pour acheter l'espèce Le prix de l'espèce est bas et on a toujours l'argent pour en acheter La plupart de l'espèce n'est pas vendue pour gagner de l'argent, mais consommer par eux-mêmes	L'argent manque pour acheter l'espèce Le prix de l'espèce est haut et on ne veut/peut pas dépenser tellement d'argent pour en acheter La plupart de l'espèce est vendu pour gagner de l'argent
Accessibilité physique de l'espèce X	L'espèce est disponible à proximité ou pas, les personnes ont l'accès aux terres ou pas	L'espèce peut être acheter ou récolter dans une distance courte Des hommes sont propriétaires des terres ou l'espèce poussent	L'espèce pousse sur une montagne qui est loin ou les marchés pour acheter l'espèce sont loin Des femmes n'ont pas accès aux terres et ne sont pas propriétaires des espèces
Temps et efforts pour	Charge de travail pour cultiver, acquérir et préparer l'espèce X	Il y a toujours du temps et de main d'œuvre	En période pluviale les personnes sont occupées avec les travaux

consommer l'espèce X		disponible pour aller récolter et préparer l'espèce La cuisson de l'espèce est courte	champêtres et ils n'ont pas le temps à récolter, conserver etc. l'espèce La récolte est pénible parce que les capsules piquent, les graines sont trop petites, il y a des épines etc.
Rôles sociaux par rapport l'espèce X	Répartition des travaux de la récolte, préparation et prise de décisions au sein des ménages	Les travaux sont repartis de manière égale et tout le monde aide à cultiver, récolter et préparer l'espèce Tous les membres de la famille peuvent décider de manger l'espèce	Des hommes priorisent les cultures de rente qui fait qu'ils n'aident pas aux femmes à cultiver et récolter l'espèce Le chef du ménage n'a pas d'intérêt à consommer l'espèce, alors les autres membres du ménage ne consomment aussi pas
Normes, règlements, tabous par rapport l'espèce X	Règlements par rapport à la culture, récolte, préparation et consommation de l'espèce X	Tout le monde est autorisé à (re)produire, récolter, consommer l'espèce On donne l'espèce particulièrement aux enfants/femmes enceintes etc. parce que c'est bon pour eux	C'est seulement un aliment pour les enfants et pas pour des adultes L'espèce est considérée comme plante sauvage et les personnes ne reproduisent pas/il y a un tabou par rapport à la reproduction ou consommation de l'espèce
Classification de l'espèce X	Opinion et perception de l'espèce X	On est fière de consommer l'espèce parque ça fait partie de l'identité culinaire L'espèce est particulièrement préparée pour des cérémonies	L'espèce est considérée une plante qui pousse dans des endroits non-hygiéniques et on n'aime pas aller y récolter L'espèce est considérée comme étrange/aliment de famine/aliment pour les animaux etc.
Connaissances de l'écologie et biologie de l'espèce X	Savoirs sur la reproduction, sur l'entretien et récolte de l'espèce X	L'espèce est bien entretenue que fait que la production augmente	Pas d'entretien est fait ce qui fait que la production de l'espèce diminue

		L'espèce est bien protégée des singes ou des ravageurs	On n'a pas de connaissances comment reproduire l'espèce, comment protéger contre les ravageurs etc.
Habitudes alimentaires par rapport à l'espèce X	Intégration de l'espèce X dans les habitudes alimentaires	L'espèce a une place importante dans l'alimentation On sait comment préparer et cultiver l'espèce et ces connaissances sont transmis des parents aux enfants	L'espèce est seulement mangée occasionnellement On ne sait pas comment préparer et consommer l'espèce et on n'a pas appris ça des parents
Connaissances sur l'utilité de l'espèce X	Sensibilisation sur les bénéfices de l'espèce X pour la santé	Les vertus de l'espèce sont connues et pourtant on essaie de consommer l'espèce beaucoup Même si l'espèce ne rassasie pas, on la consomme pour améliorer sa santé	On ne sait pas que l'espèce est bonne pour la sante L'espèce ne rassasie pas, alors on ne voit pas pourquoi il faudrait en consommer
Préférences sensorielles pour l'espèce X	Considération du gout et d'odeur de l'espèce X	Goût est savoureux, doux etc. ce qui fait qu'on consomme l'espèce plus	Goût est acide, amère etc. ce qui fait qu'on n'aime pas en consommer trop L'odeur est trop fort ce qui fait qu'on n'aime pas consommer

2.5 Il y a-t-il d'autres facteurs desquels on n'a pas encore parlé, qui limitent ou facilitent également votre consommation de l'espèce?
2.6 Vous avez mentionné que les facteurs (…) empêchent votre consommation. Quelles sont les facteurs qui empêchent le plus votre consommation de l'espèce X?
2.7 Vous avez mentionné que les facteurs (…) ont une influence positive sur votre consommation. Quelles sont les facteurs qui favorisent le plus votre consommation de l'espèce X?

3. Conclusion sur toutes les espèces
3.1 Lesquelles des espèces aimeriez-vous consommer plus souvent/en plus grand quantité à l'avenir?
- Pouvez-vous classez les espèces en termes de vos préférences pour l'augmentation de consommation? *(Photos)*
- Quelles sont les raisons pour lesquelles vous êtes plus/moins intéressés à consommer les espèces?

3.2 Qu'est-ce qui vous aiderait à augmenter la consommation de ces espèces?
- Qu'est-ce que vous personnellement pourriez faire pour consommer ces espèces plus?
- Qu'est-ce qui devrait changer dans votre environnement et dans la société?

- Comment les conseillers de nutrition/santé/agriculture pourraient-ils vous aider?

3.3 Avez-vous autre chose que vous aimeriez partager?

4. Caractéristiques sociodémographiques

13.5. Frequency of selection of NUS in the semi-structured interviews

Table 22 Frequency of selection of NUS for in-depth discussion with local experts

Selected species Respondents	A. digitata	B. aegyptiaca	B. sapida	C. gynandra	D. microcarpum	H. sabdariffa	M. oleifera	O. gratissimum	T. indica	P. biglobosa	V. radiata	Total
Local expert 1	I	I				I					I	4
Local expert 2							I		I	I		3
Local expert 3		I			I			I	I			4
Local expert 4									I	I	I	3
Local expert 5						I		I			I	3
Local expert 6		I	I							I		3
Local expert 7	I			I		I						3
Local expert 8	I		I								I	3
Local expert 9					I		I	I				3
Local expert 10	I		I							I		3
Local expert 11				I		I			I			3
Local expert 12						I	I		I	I		4
Local expert 13	I				I			I			I	4
Local expert 14				I			I				I	3
Local expert 15	I						I		I			3
Local expert 16	I	I					I		I			4
Local expert 17			I			I		I				3
Local expert 18			I		I		I					3
Local expert 19		I			I			I				3
Local expert 20		I			I			I				3
Local expert 21		I				I	I					3
Local expert 22			I							I	I	3
Local expert 23	I			I					I			3
Local expert 24			I		I		I					3
Total	**8**	**7**	**7**	**4**	**7**	**7**	**9**	**7**	**8**	**6**	**7**	**Arithmetic mean = 7**

Table 23 Frequency of selection of NUS for in-depth discussion with professional experts

Selected species / Respondents	A. digitata	B. aegyptiaca	B. sapida	C. gynandra	D. microcarpum	H. sabdariffa	M. oleifera	O. gratissimum	P. biglobosa	T. indica	V. radiata	Total
Professional expert 1	I	I	I	I	I	I	I	I	I	I	I	11
Professional expert 2					I			I	I		I	**5**
Professional expert 3			I			I		I				**3**
Professional expert 4		I			I						I	**3**
Professional expert 5							I			I		**2**
Professional expert 6					I	I					I	**3**
Professional expert 7							I	I		I		**3**
Professional expert 8		I							I			**2**
Professional expert 9	I					I	I					**3**
Professional expert 10			I						I			**2**
Professional expert 11	I			I				I				**3**
Professional expert 12		I			I				I			**3**
Professional expert 13	I	I					I					**3**
Professional expert 14	I		I				I					**3**
Professional expert 15							I		I			**2**
Professional expert 16	I	I	I	I	I	I	I	I	I	I	I	11
Professional expert 17	I				I		I					**3**
Professional expert 18	I		I	I								**3**
Total	**8**	**6**	**6**	**4**	**7**	**5**	**9**	**6**	**7**	**4**	**5**	**Arithmetic mean = 6**

13.6. Changes in the personal food environment and their influence on consumption

Table 24 Changes in the personal food environment and their influence on consumption

Change of factors	Plant species Plant part Influence on consumption	*A. digitata* Kernels +	-	/	*A. digitata* Leaves +	-	/	*A. digitata* Pulps +	-	/	*B. aegyptiaca* Pulps +	-	/	*B. sapida* Arils +	-	/	*C. gynandra* Leaves +	-	/	*D. microcarpum* Pulps +	-	/	*H. sabdariffa* Calyces +	-	/	*H. sabdariffa* Leaves +	-	/	*H. sabdariffa* Seeds +	-	/	*O. gratissimum* Leaves +	-	/	*M. oleifera* Leaves +	-	/	*P. biglobosa* Pulps +	-	/	*P. biglobosa* Seeds +	-	/	*T. indica* Pulps +	-	/	*V. radiata* Seeds +	-	/
Accessibility	↑		x			x			x			x			x			x			x			x			x			x			x			x			x			x			x	
	↓																																															
	/						x																																									
Affordability	↑					x			x						x																																	
	↓												x						x																												
	/																												x																		
Convience	↑																																														
	↓														x										x																					
	/		x	x		x	x		x	x																																					
Informal institutions	↑			x			x																																								
	↓		x			x			x						x																															
	/																																														
Social markers	↑																																														
	↓											x			x						x																									
	/		x	x		x	x		x	x			x			x						x																								
Biological and ecological know-ledge and skills	↑														x				x																												
	↓					x						x			x						x																									
	/			x			x			x			x			x									x																					
Food and nutritional know-ledge and skills	↑														x				x						x																					
	↓					x			x			x			x																															
	/												x									x																								
Sensory properties	↑																																														
	↓																					x																								
	/									x			x			x									x																					
Physiolocial status	↑																																														
	↓					x			x																																						
	/																																														

x: applicable combination, ↑: increase of factor, ↓: decrease of factor, /: no change of factor, +: positive influence, -: negative influence, /: no influence