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SCALING UP AFRICAN BAOBAB FOOD PRODUCTS VALUATION THROUGH ENHANCEMENT OF THEIR SAFETY AND VALUE CHAINS FOR FOOD AND NUTRITIONAL SECURITY IN BENIN

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Scaling up African baobab food products valuation through enhancement of their safety and value chains for food and nutritional security in Benin (West-Africa)

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Abstract

The African Baobab is a strategic indigenous tree species of sub-Sahara Africa. Its pulp is highly nutraceutical and is used as food ingredient and dietary supplement in Africa, EU and America. Locally, the pulp is used for several products. Leaves are also highly nutritious and nutraceutical with increasing demand too. As a result, pulp and leaves are overharvested in the wild, jeopardizing the species natural stands. Domestication of baobab has become urgent and several researches have been carried out to speed this process, though several aspects are still uncovered. With the growing local/global market around baobab products it becomes imperative to structure/upgrade its value chain (VC) which yet has been so far disregarded in national state agenda, in spite of its demonstrated potential to promote pro-poor growth, especially women who are specialized in baobab products related activities. Taking advantage root on technical evidences and knowledge products generated by two recent (2015-2017) RUFORUM-GRG projects (125 & 135) in Benin, this project aims to develop a sustainable and competitive baobab VC in Benin. The project is built around six work-packages and will facilitate university-TVET and community linkages to upgrade baobab products VC while contributing to improve farmers' livelihoods and baobab conservation.

Keywords: Baobab, promising doses, experiments, domestication, Benin.

Résumé

Le baobab africain est une espèce d'arbre indigène stratégique de l'Afrique subsaharienne. Sa pulpe est très nutraceutique et est utilisée comme ingrédient et complément alimentaire en Afrique, en Europe et en Amérique. Sur le plan local, la pulpe est utilisée dans plusieurs produits. Les feuilles sont également très nutritives et nutraceutiques et fortement demandées. En conséquence, la pulpe et les feuilles sont surexploitées dans la nature, mettant en péril les peuplements naturels de l'espèce. La domestication du baobab est devenue urgente et plusieurs recherches ont été menées pour accélérer ce processus, toutefois, plusieurs aspects sont toujours non élucidés. Avec le florissant marché local / mondial autour des produits du baobab, il devient impératif de structurer / améliorer sa chaîne de valeurs qui a été jusqu'ici ignorée dans l'agenda national, malgré son potentiel démontré de promouvoir une croissance favorable aux pauvres, en particulier les femmes spécialisées dans les activités relatives aux produits du baobab. En se basant sur les évidences techniques et les résultats générés par deux projets récents (2015-2017) du RUFORUM-GRG (125 et 135) au Bénin, ce projet vise à développer une filière de baobab durable et compétitive au Bénin. Le projet s'articule autour de six paquets de travail et facilitera les liens entre l'université et les Institutions d'enseignement et de formation techniques (TVET) et les communautés afin

d'améliorer les produits de la chaine de valeurs du baobab tout en contribuant à l'amélioration des moyens de subsistance des agriculteurs et la conservation du baobab.

Mots clés : Baobab, dosage, expérimentation, domestication, Bénin.

Introduction (background, problem and justification of the study, research questions/objectives & hypotheses)

Benin republic, despite its relatively stable democratic system, remains one of the poorest countries in the World. Almost 40 percent of its population lives below the poverty line (UNDP 2016). In this country, food and nutrition security is still challenging, and this challenge will be higher in the future given the risen population. The country relies heavily on agriculture (70 percent of the country's workforce) for food security and economic development. However, agricultural production is limited by factors including a lack of modern farming technologies, poor soil and inadequate conditions for storing, preserving and processing food, showing that the overall food security, nutrition and trade conditions are poor (FAO 2015). In these conditions, inhabitants and particularly children (0-5 years) and women in reproductive age face major threats such as micronutrient deficiencies which highly affect their well-being. For example, high anaemia rates (78.1 % in children under 5 years and 61.3 % in women of reproductive age) are due to iron deficiency (INSAE & Macro International Inc. 2007). With such an alarming picture, improvement of food and nutrition security becomes a must. To efficiently address these issues, wild edible plants and their derived foods come to be an excellent source to explore. These resources often rich in micronutrients can be used in food-to-food fortification. Then, if well structured, their value chains can strategically contribute to improving farmers' revenues and hence improve their livelihoods. These resources are also hands-on and local people use them raw, or partially processed. Among them, is the African baobab (*Adansonia digitata* L.), one of the most remarkable trees of the world (Gebauer et al. 2016). Several studies in different African countries have highlighted this indigenous fruit tree as a priority species for domestication and expanded use (Gebauer et al. 2016). In many countries in West Africa including Benin, its leaves, and fruit pulp are the main ingredients in sauces, porridges and beverages preparation (Chadare et al. 2009). Recently, baobab has been referred to as a "superfruit" based on its nutritional profile (e.g. vitamin, fatty acid, mineral) (Gruenwald 2009). For example, the consumption of 40 g of baobab pulp provides 100% of the recommended daily intake of vitamin C in pregnant women (19–30 years) (Chadare et al. 2009). Its fruit pulp has very high vitamin C content (up to 500 mg/100g dw, ~ ten times more that of orange, and three times the that of chocolate milk), hence high anti-oxidant properties. Its leaves contain important amounts of minerals namely Iron and Calcium and vitamins such as pro Vitamin A (Chadare et al. 2009, Chadare et al. 2014). Due to this exceptional nutritional value, baobab has been acknowledged as a novel food by the European Union in 2008 (regulation EC N°258/97 of the European Parliament) and also accepted as food ingredients in the US.

Despite the huge nutritious and economic importance of the species pulp, leaves and derived products, their Value Chains in Sub Saharan Africa are still under developed. Indeed, the species food products are still facing some challenges namely: (i) low competitiveness of actors along the entire Value Chains, (ii) safety of post-harvest leaves and pulp handling making necessary to develop a Hazard Analysis and Critical Control Point (HACCP) plan for safety leaves and pulp, (iii) lack of or limited knowledge of private and public service providers concerning appropriate technology packages to promote baobab products, (iv) inappropriate rural development policies and programmes focusing on baobab, and (v) widespread mistrust between VC operators, as well as between private and public stakeholders, making necessary to establish an operating platform involving all stakeholders. Though the production of the pulp is seasonal, techniques are being developed for its sounds storage to have adequate pulp throughout the year. For that, several studies and initiatives focused on baobab, and the project team members have substantially contributed (see Assogbadjo et al. 2009, Chadare et al. 2009, 2014, Hounsou-Dindin et al. 2016). These studies showed the potential of baobab for entering broader value-chains with a valuable contribution to sustainable agribusiness. However, overexploitation of fruits, has caused decline of the species population due to lack of natural regeneration (Sanchez et al. 2010). Also, repetitive harvest of leaves from reproductive wild trees gives rise to reduced and late fruit production and ultimately to population decline. Therefore, to ensure

sustainability (i.e. avoid relying on wild baobab trees which are declining) given the rising demand, it is a requirement that farmers engage in the production of both leaves and fruit, hence baobab cultivation. Baobab is a long live tree that produced its first fruit in average after 12 years, while leaves are produced earlier, after three months of planting. Recent studies conducted in Kenya showed that baobab can be successfully grafted. With this method baobab can start fruiting earlier than in the wild, approximately after 3 years, which is an exceptional scientific achievement, and a great asset for baobab fruit pulp market (Anjarwalla et al. 2017). Yet, this technique has not been tested in Benin, and is still not accessible to farmers. In addition, performance of such techniques may be affected by biotic (pests, competition, etc.) and abiotic conditions (precipitation, temperature, humidity, soil etc.) which greatly vary across countries. It is therefore necessary to engage research for science-based advice and guidance of farmers and nurture the existing value-chains.

Based on the above demonstrated challenges, the project aims to combine both participatory research and capacity building actions to set a long lasting valorization scheme for the African baobab at a national scale in Benin. Specifically, the project will [i]-diagnose baobab leaves and fruit pulp value chains, [ii]-organize actors involved in baobab leaves and fruit pulp value chains (VC) into a platform and networks to ensure long lasting connections, [iii]-develop market driven technological packages for baobab leaves and fruit pulp and derived-products to allow baobab cultivation and supply the market with safety and quality baobab derived-products, [iv]-establish pilot incubators for baobab leaves and fruit pulp valorization in the project areas, [v]-scale-up added-value novel technologies at country level, and [vi]-develop an advocacy plan for better integration of baobab products in food and nutrition security strategies but also as agro-business opportunity at national level.

The main hypothesis underlying this research project is that “strengthening the baobab value chain with the adaptation of improved production technologies and their adoption by rural gatherers, farmers and agri-entrepreneurs will enhance nutrition, food security and livelihoods in Benin”. Subsequent hypotheses are as follow: (i) Baobab VC is non-structured with disconnected stakeholders, under-performing; (ii) Baobab reproductive performances vary across the study sites; (iii) Length stem cutting and number of nodes of the cuttings positively affect their rooting and leafing abilities of the species; (iv) There is a lack of safety during post-harvest handling of baobab leaves and pulp as well baobab pulp packaging; and (v) Developed technologies are profitable but profitability differs across the production aim (leaves or pulp).

The project is prepared such that it shifts from traditional conservation and poverty alleviation approaches to the use of a business-oriented approach with pro-poor growth strategy. Partners of the project include public research institutions (LABEF, LEA, LSA), local communities, three Technical Vocational Education and Training (TVETs) institutions, Non-Governmental Organizations (Cidev-ONG, Jura-Afrique, Oe-Benin), and one private for-profit company (“La bourgeoise”).

The project focus and implementation (activities and methodology**)**

The project is organized in six work packages (WP): WP1 - Diagnosis and mapping of the baobab value chains; WP2 - Participative organization of actors involved in baobab value chains; WP3 - Capacity building on market driven technological packages; WP4 - Establishment of pilot incubators for baobab products valorization in each project zones; WP5 - Assessment of farmers’ perceptions and adoption of the market driven technological packages and the impact on household welfare (income, food security) and establishment of baobab garden/plantation, and WP6 – Scaling-up the novel technologies at country level through an advocacy plan for better integration of baobab products in food and nutrition security strategies at national scale.

WP1: The diagnosis will consist in three major activities as follow:

(i) Collaborative mapping of the baobab products value chain: Through stakeholder’s meetings and survey, the structure (links and actors) will be mapped and roles/responsibilities will be analyzed.

(ii) Assessment of the economic potential and environment of the baobab products value chains: Using market test and economic analyses, the market and value adding potential as well as

the gain distribution will be estimated at different stages of the VC; Using network analysis, the VC governance structure, functioning, and supporting institutions will be described as well as political, legal, administrative and infrastructural framework conditions.

(iii) Participatory assessment of opportunities/constraints for leverage points identification: SWOT analysis will be coupled with an analytic hierarchy process (AHP) to describe supporting and inhibitor factors. Using root causes analysis, the challenges and opportunities that are critical for baobab products value chain (BP-VC) development will be identified, and hence used as points of leverage to either overcome constraints or to seize opportunities.

This diagnosis will result in (1) identification of stakeholders (VC operators, VC supporters and VC enablers) and existing networks; (2) clarifying the roles and responsibilities of all stakeholders for the performance and competitiveness of the VC and understanding of the degree and structures of interdependencies between the different stakeholders; (3) economic characteristics of the VC that covers market potential, cost-benefit relations and return on investments; (4) knowledge on benefit distribution among operators along the VC; (5) knowledge of the efficiency or deficiencies of linkage management by VC operators along the VC; (6) description of the institutions supporting the VCD, including strengths, weaknesses, opportunities and threats (SWOT), as well as needs for upgrading the capacities of service providers; and (7) description of the political, legal, administrative and infrastructural framework conditions, including analysis of their impact on VCD, and need for change.

WP2: Based on the detailed knowledge of the VC from the previous WP, this second WP through participative approach, will organize actors involved in baobab value chains with the ultimate goal of creating a platform of actors and a strong network. This WP will be organized around two main activities:

(i) ***Co-creation of platform involving all actors***. The platform will involve farmers, farmers' associations, NGO working with farmers, women associations working within the baobab VC, the national business institutions;

(ii) ***Training of actors at micro, meso and macro levels involved in the baobab VC and linking actors horizontally and vertically to boost the value chain***. This activity will be achieved through a three-day workshop whereby a baobab products fair will be organized and presentations made on the baobab VC. This will contribute to attract more attention on the project. Ministry of industry will be invited to lunch the workshop along with the rector of the University of Abomey-Calavi and the vice-dean of the Faculty of Agronomic Sciences.

WP3: In this WP, the capacity building will mainly involve baobab raw material (leaves and pulp) producers/collectors, baobab products processors and marketers. This WP will consist in both research and training. Research experiments to *identify best vegetative propagation methods to supply with early producing baobab tree.* The research team has developed through a previous RUFORUM-GRG grant, a technical manual for producing baobab leaves from seed in a time frame of three months. This was a significant contribution in domesticating baobab. While this has been achieved for the production of leaves, less was done for precocious baobab fruiting. Precocious baobab fruiting is however necessary to support the increasing demand for baobab pulp. Vegetative propagation techniques are known to make possible precocious fruiting (Anjarwalla et al. 2017, Akinnifesi et al. 2006). Two vegetative propagation techniques will be examined in this project, namely grafting and aerial marcotting. Grafting has been recently tested successfully in Kenya (see Anjarwalla et al. 2017) and need to be tested in Benin conditions. To our knowledge little is known on baobab marcotting which, if successful is also a good way to quickly reproduce baobab. One M.Sc. student will work on the grafting technic in the three climatic regions of the country and another M.Sc. student will work on the marcotting also in the three regions. Each M.Sc. student will be assisted by two B.Sc. For the grafting experiments, baobab scions will be collected in different zones from the top part of the vigorous plus tree crown. Scions of about 20 cm length will be grafted on rootstocks of different ages (2 years, 3 years, 4 years, 5 years). These trees exist from previous projects (RUFORUM-GRG, CORAF). A factorial three-design with two replicates of 10 scions will be used. The three factors to be considered are: factor 1 = rootstock age (2 years, 3 years, 4 years, 5 years); factor 2=grafting method (Top cleft and side veneer grafting methods); factor 3=mother tree. The 'new shoot', first branch developing from an active bud of the

scion (and bearing new leaves) will be used to assess performance of the trials. Data will be collected on grafting success and the length of tagged new shoot produced. The most promising technique will be identified and used to train farmers during training workshops to inform and sensitize local people (farmers, extensionists, NGOs, and other stakeholders) on the best vegetative propagation methods. Each of the three TVETs with their 30 students will collaborate to lead this experiment. As far as experimentation for aerial marcotting is concerned, trees of 5 different ages (2 years, 3 years, 4 years, 5 years, 6-10 years: such trees exist from previous projects [RUFORUM-GRG, CORAF, DADOBAT]) will be combined with two substrates (sand and sawdust) to assess success of marcotting. At this step, the watering regime will be normal. Successful marcots will be transplanted. But at the transplantation stage, water stress may become a constraint and then negatively affect the regrowth. Therefore, at transplantation stage, two water regimes (normal water requirements versus stress) will be examined to identify which tree age and substrate better respond to water stress. Findings will help developing technical manual for successful marcotting of baobab and will next be used to train farmers. Therefore, in each region, a two-day training session will be done to demonstrate to farmers how young baobab trees can be cultivated to produce leaves and how vegetative propagation of baobab can be implemented for precocious fruiting. The ultimate goal behind this activity is to increase the supply of baobab products without jeopardizing the natural baobab trees.

Also, in this WP, capacity of involved actors in BVC (farmers, processors, wholesalers and retailers) will be building for post-harvest handling. For that, a research will be implemented to develop a HACCP plan for ensuring safety of baobab leaves and pulp. This work will consist in: (i) a hazard analysis of the traditional pulp extraction, (ii) elaboration of an HACC plan for pulp extraction for women association involved in the activity. In first place, HACCP team including processors and food scientists will develop a list of ingredients, materials and equipment used in the extraction of baobab pulp. Then, a process flow diagram of the baobab pulp extraction will be developed using a participative method involving the HACCP team. From this point, a hazard and risk analysis will be performed to identify the critical points which are important to monitor to ensure safety of the pulp to be produced. The seven (7) principles of the HACCP plan will be used to develop an appropriate HACCP plan for the traditional extraction of baobab pulp: (i) conduct a hazard analysis, (ii) determine the critical control points (CCPs), (iii) establish critical limits, (iv): establish monitoring procedures, (v) establish corrective actions, (vi) establish verification procedures, (vii) establish recordkeeping and documentation procedures. Next to the development of a HACCP plan for both baobab leaves and pulp, one pilot farmers' model processing unit with the contribution of partner NGOs will be set up in each region. This pilot unit will serve for training farmers on baobab leaves and baobab pulp post-harvest handling and conditioning for optimal baobab pulp and leaves powder conditioning.

WP4: This WP consists of two main activities: (i) Establishment of demonstration plots for baobab leave and pulp production to train actors of the value chain. This demonstration plot will look like an allotment garden of about 3 ha per region in each pilot site (three sites in total: one per region). A local management community will be set up and farmers willing to establish plot will be voluntarily given one pending filling the contract, terms and the condition of use which will be defined by the local committee under the authority of the village head and the commune. TVET of each of the three regions will lead the management of this garden in collaboration with local authorities. The 30 students from the TVETs will be trained in writing business plan and applying for funding at the national youth business fund. (ii) Establishment of units for baobab pulp and leaves post-harvest handling to guarantee food safety, increase their competitiveness and to train actors of the value chains: A processing unit will consist of installing equipment for packaging dried baobab leaves and baobab pulp.

WP5: This WP stands as an impact assessment of all research and capacity building activities that have been done so far (from the first year of the project to now) before scaling the novel technologies at country level. Indicators of success will include (but not limited to): (i) number of baobab seedlings or young trees per farmers, (ii) number and proportion of farmers with baobab young trees on their farms, (iii) number and proportion of farmers who have tried planting baobab trees, (iv) number and proportion of women with baobab young trees on their farms/gardens, (v) number and proportion of women who have used the fortified food-to-food formula, (vi) number and proportion of

infant-children malnutrition, etc. The study design will be as follow: two types of village will be considered in each region, *control village* where no activity of the project has been implemented and *intervention village* (where all activities of the project have been conducted). In each village, baseline survey and endline survey (6 months before the end of the) will be conducted and data will be collected on the above indicators of success. Difference-in-difference (D.i.D) approach (Abadie 2005) will be used for data analysis.

WP6: It will consist in (i) developing advocacy plan toward policy makers at national, departmental and municipal to sustain functioning baobab value chain in Benin, (ii) enhancing market penetration and market access for the actors, (iii) creating an institutional framework including all stakeholders and connect it with other institutions of interests (private and public), and (iv) formalize the governance structure of the value chain.

Expected outputs and impacts of the project

The expected outputs to be delivered are as follow: [i] baobab leaves and fruit pulp value chains diagnosed and mapped in Benin, [ii] operating platform and networks actors of baobab leaves and fruit pulp value chains, [iii] market driven technological packages developed for baobab leaves and fruit pulp and derived-products, and stakeholders capacitated on these technologies, [iv] operating pilot start-up incubators for baobab products valorization in the project areas, [v] added-value novel technologies for baobab leaves and fruit pulp and derived-products scaled up country level, [vi] 1 PhD, 5 M.Sc., and 30 TVET students trained for impact-oriented research, and [vii] maintenance of collaborative working relations among researchers, farmers, market actors, national agricultural research and advocacy institutions, and government, TVETs.

The direct impact of the project will reach 300 farmers, 60 small and medium-sized enterprises involved in baobab leaves, fruit pulp and derived-products value chains, and 36 students. The targets groups include young, women, farmers' associations, TVETs, NGOs, students, and researchers. The project seeks to promote and nurture long term partnership between public research institutions, local communities, TVETs, NGOs, and private for-profit companies. The project envisages to improve actors' revenue through better organization of the value chains while contributing to food security and nutrition of households as well as sustainable conservation of baobab trees. Accordingly, through the development of the baobab value chains, this project is expected to stimulate the local economy through the development of business aspects of farming, postharvest handling and processing of baobab products. Some expected development milestones include: [i] stakeholders along the baobab value chains in Benin are connected, [ii] supply of raw materials (baobab leaves and pulp) is increased while pressure on wild population of the species is reduced, [iii] the safety and standard of baobab pulp and leaves are improved, [iv] new enterprises for valuing baobab products were created, [v] maximum of the add value generated by the chain benefits the local people (smallholders' and processors), and [vi] livelihood of baobab smallholders' farmers and processors is improved. Through its objectives, the project will strategically contribute to the fulfilment of the RUFORUM's vision since it aligns with its vision as well as the MasterCard Foundation mission. By contributing to agricultural diversification, safety baobab products, and improving farmers' revenues with emphasis on youth and women, the project also aligns with the Malabo declaration of African Union on accelerated agricultural growth but also the UN-SDGs (end poverty, zero hunger, good health and well-being, and gender equality).

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References

Abadie A. 2005. Semiparametric Difference-in-Differences Estimators. The Review of Economic Studies, 72(1): 1–19, DOI: 10.1111/0034-6527.00321

Akinnifesi, F. K., Kwesiga, F., Mhango, J., Chilanga, T., Mkonda, A., Kadu, C. A. C., ... & Ramadhani, T. 2006. Towards the development of miombo fruit trees as commercial tree crops in southern Africa. Forests, Trees and Livelihoods, 16(1), 103-121.

Assogbadjo, A.E., Kyndt, T., Chadare, F., Sinsin, B., Gheysen, G., Eyog-Matig, O. and Van Damme, P. 2009. Genetic fingerprinting using AFLP cannot distinguish traditionally classified baobab morphotypes. Agroforestry systems 75:157-165.

Chadare, F. J., G. J. E. J. Hooiveld, A. R. Linnemann, M. J. R. Nout, and D. J. Hounhouigan. 2014. Effect of Cooking on in Vitro Solubility of Minerals and Carotenoids in Adansonia digitata. Annales des sciences agronomiques 18:1-19.

Chadare, F. J., A. R. Linnemann, J. D. Hounhouigan, M. J. R. Nout, and M. A. J. S. van Boekel. 2009. Baobab food products: a review on their composition and nutritional value. Critical Reviews in Food Science and Nutrition 49:254-274.

FAO 2015. Regional overview of food insecurity in Africa. African food security prospects brighter than ever. Accra, FAO.

Gebauer, J., Adam, Y.O., Sanchez, A.C. et al. 2016. Africa's wooden elephant: the baobab tree (*Adansonia digitata* L.) in Sudan and Kenya: a review. Genet Resour Crop Evol 63(3): 377–399. DOI: 10.1007/s10722-015-0360-1

Gruenwald, J. 2009. Novel botanical ingredients for beverages. Clinics in Dermatology 27(2): 210–216, DOI: 10.1016/j.clindermatol.2008.11.003

Hounsou-Dindin, G., Assogbadjo, A.E., Idohou, R., Salako, V.K. & Glèlè Kakaï, R. 2016. Morphological variation of baobab fruits and seeds traits in smallholders farming systems in Benin: a preliminary study on baobab leaves production. RUFORUM Working Document Series 14 (2): 979 - 985. ISSN 1607-9345. 14 (2): 613 – 620.

Institut National de la statistique et de l'analyse économique (INSAE) [Bénin] et Macro International Inc. 2007. Enquête démographique et de santé (EDSB-III)-Bénin 2006. Institut National de la statistique et de l'analyse économique Bénin et Macro International Inc., Claverton, Maryland, USA, 492 p.

Anjarwalla, P., Ofori, D., Owino, A., Matuku, D., Adika, W., Njogu, K. & Kehlenbeck, K. 2017. Testing different grafting methods for vegetative propagation of baobab (*Adansonia digitata* L.) in Kenya to assist its domestication and promote cultivation. Forests, Trees and Livelihoods 26(2): 85-95, DOI: 10.1080/14728028.2016.1202791

Sanchez, A.C., Osborne, P.E. & Haq, N. 2010. Identifying the global potential for baobab tree cultivation using ecological niche modelling. Agroforest. Syst. 80 (2):191–201. DOI: 10.1007/s10457-010-9282-2

UNDP 2016. Human development report. New York, USA. 286p.

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Traditional utilization of the top ten priority Wild Edible Plants (WEP) in Benin: a review

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ABSTRACT

Wild Edible Plants (WEP) play an important role in food security locally. Relevant studies have been performed and published on a diversity of WEP at different scales but remain scattered. This study aimed to inform on utilization of top priority WEP in Benin. Data on socio-economic importance of the species were collected from litterature combining digital and numerical approach. Results showed that the ten top priority species for economic valorization are: *Vitellaria paradoxa, Parkia biglobosa, Adansonia digitata, Irvingia gabonensis, Blighia sapida, Tamarindus indica, Dialium guineense, Vitex doniana, Borassus aethiopum and Garcinia kola.* They are mainly used for food, medicine, craft industry, wood, construction and cosmetics and contribute to income generation. Several derived products provide from from the species. *Adansonia digitata* appeared to be the species that provide the highest number of or the most important derived products (up to 35 derivd products with baobab pulp as a very important one with high economic value); and is followed by*V. paradoxa* (with shea butter as a very important product with high economic value) and *P. biglobosa* (with fermented condiment as a very important fermented product in African food culture). The species with the lowest number or least important derived product are *G. Cola*, *V. doniana* and *D. guineense*. The value chain of products from the top ten species is facing many constrainsts. Further investigation should target food and nutritional valuation of the reported products, their stabilization and their upgrading for more profitable markets for their integration in national food policies to meet food and nutrition security.

Keywords: Wild Edible food uses, medicinal uses, valuation, West Africa

Introduction

Food problems have been haunting humankind since immemorial time (Hazell & Wood, 2008). A large number of rural families in sub-Saharan Africa is facing chronic food insecurity and cannot recover even in a good growing season. With such a picture, the promotion of Wild Edible plants (WEP) for food

security becomes an asset. In Southern Ghana, it was estimated that 258,000 people gain a substantial part of their income from natural foods among which WEP (Townson, 1995). Other studies have pointed out the socio-economic importance of wild species as reliable resources (Aly et al., 2007; War, 2007; Dossou , 2008; Pye-Smith, 2010; Assogbadjo et al., 2012). Those resources made a huge contribution to food and healthcare of almost 80% of people living in developing countries (Van Andel, 2006). According to the World Health Organization, despite their huge importance, limited efforts have been made to integrate those resources into formal plan supporting local and national development. The socio-economic contribution of those resources to livelihoods and the impact of their use on the environment are increasingly recognized worldwide. Recent studies focused on the distribution, uses, and socioeconomic importance, nutritional and food value of the species (Assogbadjo, 2006; Chadare et al. 2008; Fandohan, 2011; Gouwakinnou, 2011; Vodouhe, 2011; Houehanou, 2012; Chadare, et al., 2013). In addition, IPGRI (2002) and FAO (2014) identified the ten top prioty species to be valued in the country. It is thus timely to know more about the available potential of the priority species in order to proceed with more focused studies on value chains to be developed. The present review summarises the traditional utilization of the top 10 priority species for valuation in Benin. Research needs are identified on the basis of the findings.

Methodology

Reported data were collected through checking online databases (Googlescholar, PubMed, and Scopus) and manual search of the resources available at libraries of main universities of Benin. Collected data were related to utilization and socioeconomic importance of each species. Collected data focused on the top 10 priority WEP species of Benin as defined by FAO, (2014). Tables were used to summarize the information gathered

Results

Priority Wild Edible Plants for food security and nutrition in Benin

A recent study by FAO (2014) using a new and innovative prioritization approach (Bhrem et al., 2010) and previously successfully applied to crop wild relatives species in Benin (Idohou et al., 2013) yielded a list of 10 priority species for economic valorization. They were: *Vitellaria paradoxa*, *Parkia biglobosa*, *Adansonia digitata*, *Irvingia gabonensis*, *Blighia sapida*, *Tamarindus indica*, *Dialium guineense*, *Vitex doniana*, *Borassus aethiopum* and *Garcinia kola*.

1. Usage of the 10 priority WEPs

Top priority WEP are multipurpose species used mainly for food, medicine, cosmetics, construction, and in craft industry. Distribution of those species across Benin is very diverse (Figure 1). While some species are distributed countrywide, other species remain located to specific phytogeographical districts. Several studies dealt with WEP uses by local people in Benin (Codjia et al., 2003; Assogbadjo, 2006; Chadare et al., 2008, Ekué, 2009; Fandohan, 2011; Ahouansou et al., 2012; FAO, 2014; Idohou, 2016). According to their findings, most of WEP species organs' (fruits, flowers, leaves, bark, root, and sap) are valued raw or through pretreated or fully processed products. Fruit remains the most valued organ and is followed for most of the species by the leaves, seeds, roots/tubers, sap, and flowers (Codjia et al., 2003). Even if some efforts are recently made to process these species, techniques used are still traditional and/or semi traditional and do not allow their distribution on high standing market. A summary of the different products made from the different species is presented in table 1.

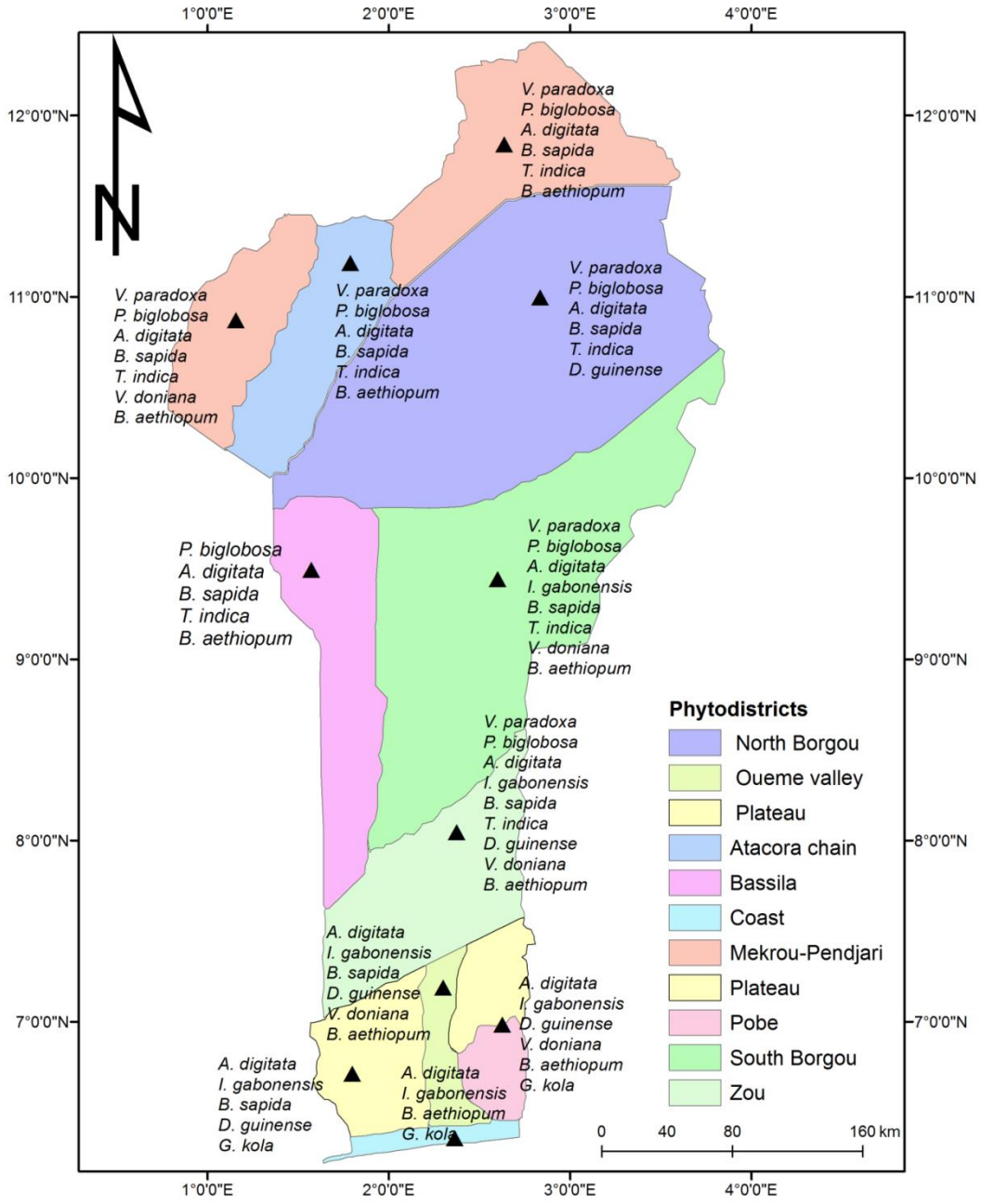

Figure 1. Location of priority Wild edible plants for economic valorization in Benin
Source: FAO (2014)

1.1. Adansonia digitata

Baobab tree is used by the rural people for food, medicinal, craft, cultural and economic purposes (Assogbadjo, 2006; Chadare et al., 2008; FAO, 2014). In Benin, the species is more valued in the North and the organs are mostly collected by women. This comes from the fact that the baobab is culturally integrated in the daily life of the populations living in that area. Consequently, the leaves are most valued in North as vegetable sauce followed by the pulp and the seeds.

Baobab leaves: In Benin, *Kouimkoundi* is a local recipe sauce made with dry baobab leaves sauce + "Afitin", a traditional fermented condiment from African locust bean (*P. biglobosa*). We have also *Yatirankounti* sauce which is made whole baobab fresh leaves while *Kouimkoundi* is made with ground

fresh or dry baobab leaves. *Touwoundou* is similar to *Kouimkoundi* except dehulled and cooked beans (*Vigna unguiculata*) are used to replace Afitin in the recipe (Chadare, et al., 2008).

Baobab pulp: The pulp of Baobab serves in making gruels, most beverage (*Nanganfirou*, *Yewowi*, pulp beverage, and *Tcho*) and *Solani*, and dough but it is also eaten as dessert whereas the seeds serve for sauce recipes. A least important product from baobab pulp is *Moukou-Moukou* (mixture of pulp and sugar) (Assogbadjo, 2006, Chadare et al., 2008). The pulp is used to produce some drinks particularly juice and syrup (Dan Guimbo et al., 2012; Chadare et al., 2008; FAO, 2014). The pulp is used in recipes of some gruel namely "mutchoyan" in local dialect in Benin and "ngalakh" in local dialect in Senegal.

Baobab seeds and kernels: The seeds of baobab, once husked, can be consumed after soaking either in acidified or alkalined cold or hot water. It could be also cooked in water, fermented in normal conditions inside banana leaves (for example) and sun-dried for 24 h or roasted. Vegetable and edible oil is extracted from the peeled seeds of baobab which also serves in some sauce recipes as thickener in Niger (Dan Guimbo et al., 2012). In Benin, some foods are derived from baobab seeds namely *kernel, Moutokpei, Matofaman, Batokoue, Dikouanyouri, Mougou-Mougou*. All of these foods are traditional sauce recipe made with whole seeds roasted and ground (*Moutokpei*), fermented baobab seeds (*Matofaman*, *Dikouanyouri*), seeds powder (*Batokoue*, *Mougoundoro*). Dikouanyouri sauce is generally made from seeds that cannot be decorticated. The difference between *Mougoundoro* and *Mougou-mougou* is about one ingredient only used in the first case. The kernel is also used to made some recipe of sauce namely *Tayohounta* (fermented product) and *Sarai* sauce (local bean included) (Chadare, et al., 2008). Another derived product is croquette of baobab which is well sold on the markets (Dan Guimbo et al., 2012).

1.2. Vittelaria paradoxa

Among the top 10 species identified, Shea butter tree is the most valorized in national and international markets in term of marketing. Indeed, fresh fruits of shea butter very consumed, its almond and particularly its butter are much commercialized (Ekué et al., 2008; FAO, 2014). In Benin, the fruits are depulped, stored for few days, then boiled and dried or smoked to extract kernels up to butter production often storage in baskets lined with teak (*Tectona grandis*) leaves, paper bags, jute bags and plastics with cover (Honfo, et al., 2012). Generally the almonds are conserved in bag or in a pot whereas the butter is conserved in pot or in calabash in rural areas. (Ahouansou et al., 2012; Honfo, et al., 2012).

1.3. Parkia biglobosa

Néré (*Parkia biglobosa*) is a WEP of which the most valued organs are the seeds to produce a condiment called "afitin" in Benin local language "Fongbe" (similar to "iru" or "sonru" with bariba and Yoruba), a local condiment very appreciated by local population (Azokpota et al., 2006; Ekué et al., 2008; Koura et al., 2011 ; Akouehou & Azokpota, 2015). This type of condiment is characterized by significant organoleptic and nutritive qualities and replaces fish or the meat in sauces in certain areas, because of its high protein content (Adepoju, 2009; Vinceti et al., 2013 ; Aguzue et al., 2013 ; Dossou et al., 2014). The fermentation time is longer in "iru/sonru" (48 h) process than in "afitin" (24 h). Consequently, iru and sonru are very soft products as they are preferred by some consumers whereas afitin is preferred with cotyledons having less soft texture (Azokpota et al., 2006). These condiments are used in almost all sauces accompanying the tuber or cereal doughs, namely: slimyy sauce (of okra or crin crin), vegetable leafy sauce or tomato sauce. They are sometimes consumed in a fresh state or are used for the preparation of "moyo", a Beninese specialty containing tomato and onion (Koura et al., 2011). The seeds

which constitute the principal food resource drawn from Parkia are very rich in proteins, lipids, mineral substances and other nutriments in considerable proportions (Akouehou & Azokpota, 2015). In general, the methods of fermentation of seeds of Parkia vary from one country to another one (Azokpota, et al., 2006; FAO, 2014).

1.4. Blighia sapida

Blighia sapida is widely recognized and used as food and medicine with a high economic and socio-cultural value (Ekué, 2009; FAO, 2014). Indeed, the fleshy arils surrounding the seeds, when ripe, are enjoyed by many people during breakfast or even in sauce parboiled or fried (Ekué, 2009). The fruit is consumed raw by children and adults and sometimes incorporated in sauce after frying or drying by local populations. Then, women use it as condiment to replace fish. Husk and soap are also derived product of this species very marketed (FAO, 2014). Leaves and barks are used together to treat sore stomachache, epilepsy and yellow fever in Columbia (Ekué, 2009).

1.5. Borasus aethiopium

Borassus tree, is among the highly valorized WEP by local people. Almost all parts of the tree (stipe, leaves, petiole, final bud, fruits, hypocotyle and roots) are used (Salako, 2016). In Benin, the most valorized part of this tree is the hypocotyle which is often eaten boiled or roasted and is much appreciated by local population (Salako, 2016). The fleshy part of the fruit is also consumed and can serve to produce an excellent juice. Petioles are used in craft industry especially for palisades, hedges, partitions of livestock building; brush (with the shortened limb). The branches and the leaves are used for making basket (Salako, 2016).

1.6. Tamarindus indica

The pulp of tamarind is used as a laxative, purgative beverage, and porridge. It also used in malaria treatment. The fruit is used in a sauce preparation as an aphrodisiac for men. It is also used to treat male impotence and against cough by Fulani and Berba respectively (Fandohan, 2011). Fruit was the only commercially valuable food part of the tree. A recent study pointed out its pulp as the most requested product of the Tamarind tree which is used by processors to produce juice either locally prepared in the zones of collection or prepared and bottled by small processing units mainly installed in northern and the southern Benin (FAO, 2014).

1.7. *Irvingia gabonensis*

The pulp of wild mango (*Irvingia gabonensis*), is consumed raw in Benin. Its almond constitutes one of the condiments most coveted by the populations in the southern because after drying and grinding, it is used to make a very special and slimy sauce very much appreciated by the population. Its nuts hold considerable place in the exchanges of the WEP in Benin (FAO, 2014; Vihotogbe et al., 2014). The bark of bush mango trees is sometimes severely stripped for medicinal purposes (Vihotogbe et al., 2014).

1.8. Vitex doniana

Vitex doniana (black pulm) leaves are used as leafy vegetables. Black pulm has many applications in traditional medicine. Decoction of the bark is used in the treatment of diarrheas. A macerated leaf mixed with alum (locally called “cidakin” in Fon) is indicated for dysentery treatment. The sap of fresh leaves is used in white-washing for stomatitis. The aqueous decoction of the leaves is used in bath of finger in the whitlows. Decoction of leaves treats headaches, rigidity, measles, the cutaneous eruptions, the fever, chicken pox and hemiplegia and by internal way is used for respiratory diseases

treatment and for tonic, febrifuge and analgesics (FAO, 2014). A crush of its barks and leaves is applied to the wounds and the burns to heal them. The hot aqueous extracts of the leaves are used against stomachache, rheumatic pains, ignitions, diarrhea and dysentery. The methanoïc extracts of its bark can be used against the gastro enteric infections. The bark also looks after the leprosy and liver diseases. The roots, the bark and the leaves are used against nauseas and colic. In addition, the fruits are used to treat anemia and the roots to treat the blennorrhea (FAO, 2014).

1.9. Garcinia Cola

Fruits of *Garcinia kola* are edible and its roots are abundantly used in pulverized form and/or infusion to treat the Ulcer of Buruli. This tree occupies a very significant place in the cultural ceremonies (FAO, 2014). To summarize, fruits of this species are usually sold on the local markets and are eaten fresh, as a collation by all age groups. The leaves, the bark and the roots are used to cure a varied range of disease whereas hard and heavy woodare used for the manufacturing of floor and other local building materials. In traditional pharmacopeia, the roots are aphrodisiacs, the bark is analgesic and is used to cure cough and the dental decay; the leaves fight against the antenatal pains, diarrhea and the asthenia. With regard to the young stems and the branches, they are used like tools of fishing (FAO, 2014).

1.10. Dialium guineense

Fruits are sold on local markets and commonly consumed by all classes of population either raw or as a drink with addition to water and sugar, some medicinal recipes (FAO, 2014). The leaves, the barks and the roots are used to heal a various range of deseases. In traditional pharmacopeia, the bark are used as analgesic and against coghing and toothache; leaves are used against prenatal pains (FAO, 2014)

Table 1: Derived products of priority Wild Edible Plants for conomic valorization in Benin

WEPs	Derived products	References
Vitellaria paradoxa	Fruits, Kernel, almond, butter	Ekué et al.(2008); Ahouansouet al.(2012); Honfo et al.(2012) ; FAO, (2014)
Parkia biglobosa	Seeds, pulps powders, afitin or « sounru » or « iru »,	Ekué et al.(2008); Koura et al.(2011); Dan Guimbo et al. (2012); FAO (2014)
Adansonia digitata	Nectar, syrups, croquettes, dried, fresh leaves, powder of leaves, gruels, dough, mutchoyan, ngalakh, oil, Nanganfirou, Yewowi, Tcho, Solani, Moukou-Moukou, Kouimkoundi, Moutokpei, Matofaman, Batokoue, Dikouanyouri, Mougou-Mougou, Tayohounta, Sarai, potash	Assogbadjo (2006); Ekué et al.,(2008);Chadare et al.(2008); Dan Guimbo et al.(2012); FAO (2014)
Irvingia gabonensis	Apple (fruit), nuts, endocarp, entire fruit, wood	FAO (2014); Vihotogbé et al.(2014)
Blighia sapida	Soap, fresh dried or fried fruit, husk, fleshy arils as condiments	Ekué (2009); FAO, (2014)

Tamarindus indica	Pulp, Juice, yokes, shafts and naves for cow harnesses,	Fandohan (2011); FAO, (2014)
Dialium guineense	Fruits, some medicinal recipes	FAO (2014)
Vitex doniana	Fruits, vegetable sauce, some tisane recipes	FAO (2014)
Borassus aethiopum	Brush, basket, boiled or roasted hypocotyle	Ekué, et al. (2008); FAO, (2014); Salako (2016).
Garcinia kola	Fruit, Nut	FAO (2014)

Conclusion

Wild Edible Plants can be valued to fight against food insecurity and undernutrition particularly in rural areas. However, the unregulated exploitation of wild plants can put severe pressure on populations and even threaten the survival of species. Greater efforts are required to ensure the sustainability of wild harvested plant products. WEP draw a high potentiality of valoraiztion in order to tackle the undernourishement in local level. But, some contraints need to be mastered to really make them useful in policy strategy. It is necessary to perform research on the food and nutritional valorisation of the reported products, their stabilization and upgrading for more remunerative markets so that they are included in national food policies to meet food and nutrition security.

Acknowledgement

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Selected references

- Ahouansou, R. H., Houssou, P., Dan, C. B., Agbobatinkpo, P., Adékambi, S., Gnonlonfin, G. J., Mensah, G. A. (2012). Savoir-faire endogènes pour la valorisation du fruit de karité au Bénin en Afrique de l'Ouest. *Bulletin de la Recherche Agronomique du Bénin (BRAB)*(71), 38-45.
- Assogbadjo , A. E. (2006). Importance socio-économique et étude de la variabilité écologique, morphologique, génétique et biochimique du baobab (Adansonia digitata L.) au Bénin. Thèse de doctorat. *Faculty of Bioscience Engineering, Ghent University, Belgium*, 213.
- FAO. (2014). Stratégie Nationale et plan d'actions de valorisation des Produits Forestiers Non Ligneux (PFNL) prioritaires du Bénin : cas des fruitiers sauvages. *Ministère de l'Environnement Chargé de la Gestion des Changements Climatiques du Reboisement de la Protection des Ressources Naturelles et Forestières/Direction Générale des Forêts et des Ressources Naturelles/Projet d'Appui à la Promotion PFNL*, 140p.
- Azokpota, P., Hounhouigan, D. J. & Nago, M. C., 2006. Microbiological and chemical changes during the fermentation of African locust bean (Parkia biglobosa) to produce afitin, iru and sonru, three traditional condiments produced in Benin. International Journal of Food Microbiology, Volume 107, p. 304 – 309.
- Chadare, F. J. et al. (2008). Indigenous knowledge and processing of Adansonia digitata L. products in Benin. Ecology of Food and Nutrition, 47(4), pp. 338-362.

- Codjia, J. C., Assogbadjo, A. E., & Ekué, M. M. (2003). Diversité et valorisation au niveau local des ressources végétales forestières alimentaires du Bénin: Études originales. *Cahiers Agricultures, 12*, 1-12.
- Ekué, M. R. (2009). Indigenous knowledge, morphological variation and genetic diversity of Blighia sapida K.D. Koenig in Benin: Dissertation of PhD. *Forest Genetics and Forest Tree Breeding, Büsgen Institute, Faculty of Forest Sciences and Forest Ecology, Georg-August University of Göttingen, Benin*, 1-165.
- Fandohan, A. B. (2011). Conservation biology of Tamarindus indica (Fabaceae) in Benin, West Africa. PhD Dissertation. *FSA/UAC*, 237.
- Honfo, F. G. et al. (2012). Indigenous Knowledge of Shea Processing and Quality Perception of Shea Products in Benin. Ecology of Food and Nutrition, Volume 51, p. 505–525.
- Idohou, R., Assogbadjo, E. A., Fandohan, B., Gouwakinnou, N. G., Glele Kakai, L. R., Sinsin, B., & Maxted, N. (2013). National inventory and prioritization of crop wild relatives case study for Benin. *Genet Resour Crop Evol, 60*, 1337–1352. doi:10.1007/s10722-012-9923-6
- Salako, K. V. (2016). Population ecology, pattern of uses and conservation of the dioecious palm tree Borassus aethiopum Mart. (Arecaceae) in Benin, West Africa: These pour l'obtention du grade de Docteur, Spécialité : Ecologie et Conservation des Plantes. *Université d'Abomey Calavi*, 1-259.

Abstract submitted by the PhD student

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Nutraceutical and antimicrobial properties of baobab pulp and leaves: a review

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Abstract

Adansonia digitata L. is a majestic tree revered in Africa for its medicinal and nutritional value. The different parts of the tree (bark, leaves and pulp) are used for different purposes. Despite the health benefits properties of the baobab pulp and leaves, few studies were related to their nutraceutical properties. The present review aimed to point out some nutraceutical properties of these parts of the fruit and their potential health benefits. Different terms related to baobab and functional properties were used on selected research's engines and the data related to this review were collected from 28 articles. The review showed that baobab leaf is rich in glycosides, saponins, steroids and flavonoids; and its extract has an inhibitory activity on some pathogenic microorganisms. Bioactive compounds such as procyanidin B2, vitamin C, gallic acid and epicatechin were found in the pulp. The pulp contains alkaloids, glycosides, steroids, coumarins, flavonoids, saponins, carbohydrates; in the family of glycosides, four hydroxycinnamic acid glycosides, six iridoid glycosides and three phenylethanoid glycosides were identified in the pulp. The efficiency of baobab pulp extract on the total blood cholesterol content and blood glucose content through the experiences made on rats and human patients was evidenced. Baobab pulp can be used against diabetes and obesity whose prevalences are increasing. The review revealed the inhibitory effect of the leaf extract on pathogenic microorganisms as *Aspergillus flavus, Staphylicoccus aureus, Escherichia coli, Salmonella typhi.* Further studies must be focused on the antimicrobial properties in food storage, and on the identification of molecules responsible of the anti-diabetic and anti-cholesterolemic effects of the baobab pulp.

Keywords. Diabetes, Obesity, Microorganisms, Nutritional, functional properties,

Introduction

Baobab or *Adansonia digitata* L. belongs to the Bombacaceae family, which consists of around 20 genera and 180 species. The tree species is found widespread throughout the hot, drier regions of tropical Africa (Gurashi et al., 2016). *Adansonia digitata* L. is a majestic tree revered in Africa for its medicinal and nutritional value. The pulp is an excellent source of antioxidant, due to the vitamin C content which is seven to ten times higher than the one of oranges (Viljoen et al., 2011). Studies conducted on baobab organs showed that crude protein, crude lipids and carbohydrates concentration ranged from 2.5 to 17 g/100g dw, 0.2 to 15.5 g/100g dw, 46.6 to 87.7 g/100 g dm respectively for baobab pulp, 10.1 to 15 g/100g dw, 4.0 to 6.3 g/100g dw, 40.2 to 69.0 g/100g dw respectively for baobab leaves (Chadare et al. 2009; Assogbadjo et al., 2012).

In the past decade, the tree received grown interest from several pharmaceutical companies and researchers due to its various medicinal, nutritional and cosmetic properties. Indeed, fruits, seeds, leaves and bark contribute to the livelihood of many tribal populations in Africa as it is a source of food, fiber and medicine (Wickens, 1982; Codjia et al., 2001; Sidibe and Williams, 2002; Chadare et al., 2009; Buchmann et al., 2009; De Caluwe et al., 2010). More than three hundred traditional uses have been collectively

documented in Benin, Mali, Zimbabwe, Cameroon, the Central African Republic, Kenya, Malawi, South Africa and Senegal (Buchmann et al., 2010). A strong demand of baobab and its derived products exist particularly in Sudan where 60 to 75% of consumers appreciate baobab products due to its nutritional value (Adam, 2017). It is becoming important to properly understand the different properties of the baobab tree and how it could play a significant role in health-promotion of human being. The increasing demand for natural ingredients improving health and appearance is also attracting beverages as the fastest growing segment on the functional food market. Functional beverages are launched as fortified water, tea, diary or juices claiming overall nutrition, energy, anti-aging or relaxing effects (Gruenwald, 2009) and constitutes an opportunity for next generations in food industries. One of the major challenges, in Africa, in the last years has been to establish the baobab as a commercial crop with an economic value (Renaud et al., 2013). In a whole, parts are used for multiple medicinal purposes in many parts of Africa and were found to show interesting medicinal properties including antioxidant, prebiotic-like activity, anti-inflammatory, analgesic, antipyretic activity, anti-diarrhoea, anti-dysentery activity and excipient (Kaboré et al., 2011). These therapeutic functions were described by many authors but their nutraceutical components were hardly assessed. The present short review aimed at contributing filling that gap by documenting nutraceutical properties of baobab pulp and leaves, and their effects on diabetes and obesity.

Methodology

The literature search was done by using the following search terms: “baobab derived products”, “functional and nutraceutical of baobab pulp”, “functional and nutraceutical properties of baobab leaves”, “Medicinal properties of baobab pulp/leaf”, “antimicrobial properties of baobab pulp and leaves” “Obesity status” and “Diabetes status”. The research’s engines used were “Google scholar”, “Web of Science”, “Scopus” and “Agora”. A total of 162 articles were consulted during the data collection and the 28 more focused articles were used in the writing of the present short review.

Results and Discussion

Obesity and Diabetes

WHO estimates that there are about 180 million obese adults, and that there are in addition at least twice as many adults who are overweight, with a Body Mass Index (BMI) of 25.0 to 29.9 (Bjorntorp, 2002). The global prevalence of obesity has doubled in recent decades and this disease was associated with lower concentrations of specific antioxidants in food which may play a role in the development of obesity related diseases such as cardiovascular disease (Hosseini et al., 2016). The prevalence of overweight and obesity among women is increasing in developing countries as well. Indeed, the number of obese persons doubled in Kenya, Benin, Niger, Rwanda, Côte d’Ivoire and Uganda, while tripled in Zambia, Burkina Faso, Mali, Malawi and Tanzania from 1993 to 2014 (Amugsi et al., 2017). Obesity was identified as an important risk factor for onset and progression of several neurological disorders; it induced dyslipidaemia, metabolic dysfunction, and inflammation are attributable to the development of a variety of effects on central nervous system (CNS) as Parkinson’s disease and Alzheimer’s disease; these metabolic changes which could alter the synaptic plasticity of the neurons and lead to neural death, affecting the normal physiology of central nervous system (Bhat et al., 2017).

The human population worldwide appears to be in the midst of an epidemic of diabetes (Rao and Tiwari, 2002).

The global prevalence of diabetes currently exceeds 400 million and is projected to increase to more than 600 million affected persons by the year 2035 and developing countries will account for the greater proportion of the projected increase in diabetes prevalence (Dagogo-Jack, 2017).

The nutraceuticals

Nutraceutical is a term which combined the words “Nutrition” and “Pharmaceutical”, is a food or food product that provides health and medical benefits, including the prevention and treatment of disease (Ujjaliya et al., 2018). A nutraceutical is also defined as any substance considered as a food or part of a food which provides medical or health benefits including the prevention or treatment of disease; it includes isolated nutrients, dietary supplements, diets and dietary plans, genetically engineered foods, herbal products and processed foods such as cereals soups and beverages (Wrick, 2005). The term Nutraceuticals is also used to design bioactive natural compounds that have health promoting or disease preventing properties (Elliott and Ong, 2002). Many food nutrients are nutraceuticals. They belong to the group of carbohydrates, lipids, proteins, minerals, fibers and Vitamins.

Nutraceutical compounds in Baobab pulp

Many studies described the potential or reported health benefits of the pulp consumption on human body. Thirteen components were reported for the first time in baobab pulp: four hydroxycinnamic acid glycosides, six iridoid glycosides and three phenylethanoid glycosides. The four hydroxycinnamic acid glycosides (HAGs) are: 1-O-(E)-feruloyl-β-D-glucose, 1-O-(E)-caffeoyl-β-D-glucose, 6-O-(E)-caffeoyl-β-D-glucose, 6-O-(E)-caffeoyl-α-D-glucose. The six iridoid glycosides are: (−) specioside, verminoside, 6-O-(E)-feruloylcatalpol, 6-O-p-coumaroylajugol, 6-O-(E)-caffeoylajugol, 6-O-(E)feruloylajugol. The three phenylethanoid glycosides are: martynoside, acteoside and isoacteoside. Hydroxycinnamic acid glycosides, iridoid glycosides and phenylethanoid glycosides were found to be the main components in baobab fruit pulp (Li et al., 2017). The iridoid glycosides and phenylethanoid glycosides were revealed to have antioxidant, anti-inflammatory, antimicrobial and antiviral effects (Li et al., 2017.

Some chemical families were found in the baobab pulp extract; they are: Tannins, Terpenoids, Alkaloids, Coumarins and Sterols (Zeitoun et al., 2016). The same compounds were found in the ethanolic extract of dried baobab pulp; they are the alkaloids, the glycosides, the steroids, the flavonoids, the saponins, the carbohydrates, the gums and the mucilage (Saravanaraj et al., 2017).

Bioactive compounds were found in baobab pulp: procyanidin B2 (533 ± 22.6 mg/100 g FW), vitamin C (AA + DHA) (466 ± 2.5 mg/100 g FW), gallic acid (68.5 ± 12.4 mg/100 g FW) and (-) epicatechin (43.0 ± 3.0 mg/100 g FW) (Marshall et al., 2017).

Nutraceutical compounds in Baobab leaves

Baobab leaves are usually used in dry form in the preparation of a soup known as “miyan kuka” in Northern Nigeria (Ogbaga et al., 2017), “Yatirankounti sauce”, “Touwoundou sauce” and “Kouimkoundi sauce” in Benin (Chadare et al., 2008). The leaves are believed to have nutritional and medicinal benefits and have been used for those purposes in Africa and Asia; however there has been limited research on the detailed constituents of the dry leaves (Ogbaga et al., 2017).

The evaluation of the presence of some phytochemicals in aqueous extract of leaves revealed that the leaves are rich in phytochemicals such as glycosides, saponins, steroids and flavonoids while alkaloids, tannins and resins are absent (Abiona et al., 2015)

Anti-microbial properties of baobab pulp and leaves

Baobab leaves have anti-microbial properties on certain microorganisms (Abiona et al., 2015). The use of its aqueous extract showed its inhibitory effect on pathogenic microorganisms, at different doses (Table 1). The table shows that baobab leaf extract has a significant effect on *Staphylococcus aureus*, at a little dose (12.5 mg/ml); it also revealed the inhibitory effect on *Escherichia coli* at a dose of 50mg/mL and *Salmonella typhi* at a dose of 100 mg/ml. *E. Coli* and *S. Typhi* are considered as target pathogens microorganisms in many food products such as juice, nectar, milk. Baobab leaves extracts could be used to prevent stomach aches and typhoid fever respectively due the inhibitory actions on *E. coli* and *S. typhi.*

Table 1: Effect of baobab leaves extract on some microorganisms

Microorganisms	**Doses** (mg of dried leaf/ml of the solution)				
	12.5	25	50	100	200
Staphylococcus aureus,	+	+	+	+	+
Escherichia coli,			+	+	+
Bacillus subtilis,		+	+	+	+
Pseudomonas aeruginosa,				+	+
Salmonella typhi,				+	+
Candida albicans,			+	+	+
Aspergillus niger,			+	+	+
Rhizopus stolomifer,				+	+
*Penicillum rotatum*at			+	+	+

+ indicates an inhibition of microorganism

Source: Abiona et al. (2015)

Baobab pulp has inhibitory effect on moulds. The use of baobab fruits extract on the vegetative growth and aflatoxin secretion by *Aspergillus flavus* (SQU21) and *Aspergillus parasiticus* (CBS921.7) strains, at different concentrations (1.5, 3, 5 and 7% w/v) revealed an inhibition of the total aflatoxin secretion up to 20.4-68.5% for *A. flavus* and 11.9-69.1% for *A. parasiticus*; whereas the inhibition of aflatoxin B1 production ranged between 29.9-79.2% and 13-68% for the two strains respectively. It indicates the antifungal activity and inhibitory effect of baobab on the growth and aflatoxin production by two toxigenic strains (El-Nagerabi et al., 2013).

Effect of the baobab pulp extract on the body

- *Anti-diabetic effect*

The use of the ethanolic extract on streptozotocin-induced diabetes rats revealed a significant effect on the blood glucose content. The experiment evidence obtained indicates that ethanolic extract of *Adansonia digitata L*. fruits possess the antidiabetic properties which suggests the presence of biologically active components which deserve further investigation and elucidation (Saravanaraj et al., 2017). Another similar experience on diabetic rats which were administrated baobab pulp extract showed, at doses lower than 5000 mg/kg, significant decrease in blood glucose level when compared to diabetic control after two weeks treatment with the extract (Muhammad et al., 2016). It involves a hypoglycemic activity of the extract which might be due to the presence of various phytochemicals in baobab pulp.

- *Anti-obesity effect*

An intervention trial conducted at Soba Hospital, Sudan, to evaluate the effects of *Adansonia digitata* pulp on serum lipids among a human population of hyperlipidemic patients revealed a notable reduction of the levels of total cholesterol (49.06 %) and triglycerides (57.44%) in the intervention group compared to the control group (Gadour et al., 2017). The intervention group were administrated with atorvastatin tablets combined with baobab pulp, while the control group received tablets of atorvastatin only; this reduction suppose a combined effect of baobab pulp and atorvastatin's tablets.

Another study on rats, revealed the effect the baobab pulp on the total cholesterol (Alhassan et al., 2016). Indeed Hyperlipidemia was induced in rats via feeding on high lipid diet for 3 weeks. The rats received different doses of baobab pulp (1.25 g/kg, 2.5 g/kg and 3.75 g/kg). The experience revealed a significant increase in the high density lipoprotein (HDL) content observed with 1.25 g/kg, 2.50 g/kg and 3.75 g/kg. *A. digitata* aqueous fruit pulp extract possesses anti-hyperlipidemic activity.

Conclusion

The multi-purposes tree, *Adansonia digitata* is still revealing its several properties and chemical substances explaining the provided different benefits. Its nutritional value is well investigated while its medicinal value is still under discovery. The present short review showed the phytochemicals or bioactive compound families identified in pulp and leaves. Some researches have proved a significant effect of pulp on diabetes and total cholesterol in rat's body and in human beings. Further studies must be focused on the identification of molecules which are responsible of the anti-diabetic and anti-cholesterolemic effects of the baobab pulp. The antimicrobial properties may also be tested in food storage experiments.

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Bibliographic references

ABIONA, D. L., ADEDAPO, Z. & SULEIMAN, M. K. 2015. Proximate Analysis, Phytochemical Screening and Antimicrobial Activity of Baobab (Adansonia digitata) Leaves. *IOSR Journal of Applied Chemistry,* 8**,** 60-65.

ALHASSAN, A. J., MUHAMMAD, I. U., JARUMI, I. K. & WUDIL, A. M. 2016. Evaluation of Anti-hyperlipidemic potentials of Aqueous fruit pulp extract of *Adansonia digitata* in experimental rats. *European Scientific Journal,* 12**,** 298-308.

ASSOGBADJO, A. E., CHADARE, F. J., KAKAÏ, R. G., FANDOHAN, B. & BAIDU-FORSON, J. J. 2012. Variation in biochemical composition of baobab (*Adansonia digitata*) pulp, leaves and seeds in relation to soil types and tree provenances. *Agriculture, Ecosystems and Environment,* 157**,** 94-99.

BHAT, F. Z., MORTONA, D. J., MASONA, S., BEKHITB, A. A. E.-D. & BHATC, H. F. 2017. Obesity and neurological disorders: Dietary perspective of a global menace. *Critical Reviews in Food Science Nutrition*.

DAGOGO-JACK, S. 2017. Primary Prevention of Type 2 Diabetes: An Imperative for Developing Countries. *Diabetes Mellitus in Developing Countries and Underserved Communities.*

GADOUR, O. M., KHIDIR, B. H., ADAM, I. & GASIM, I. G. 2017. Effects of a powder of the fruit of *Adansonia digitata* (Tabaldia, Gongolase, or baobab tree) on serum lipids. *Journal of Herbal Medecine*.

LI, X.-N., SUN, J., SHI, H., YU, L., RIDGE, C. D., MAZZOLA, E. P., OKUNJI, C., IWU, M. M., MICHEL, T. K. & CHEN, P. 2017. Profiling hydroxycinnamic acid glycosides, iridoid glycosides, and phenylethanoid glycosides in baobab fruit pulp (Adansonia digitata). *Food Research International*.

MARSHALL, L. J., HOLMES, M. J. & TEMBO, D. T. 2017. Effect of thermal treatment and storage on bioactive compounds, organic acids and antioxidant activity of baobab fruit (Adansonia digitata) pulp from Malawi. *Journal of Food Composition and Analysis,* 58**,** 40-51.

OGBAGA, C. C., NURUDDEEN, F. A., ALONGE, O. O. & NWAGBARA, O. F. 2017. Phytochemical, Elemental and Proximate Analyses of Stored, Sun-Dried and Shade Dried Baobab (Adansonia Digitata) Leaves.

SARAVANARAJ, M., MUTHUSAMY, P., RADHA, R. & JERAD SURESH, A. 2017. Anti-diabetic effect of the ethanolic extract of dried fruits of *Adansonia digitata Linn*. *World Journal of Pharmacy and Pharmaceutical Sciences,* 6**,** 1597-1605.

Abstract submitted by the MSc Student 1

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Food to food fortification with Moringa Leaf Powder and Baobab Fruit Pulp improves potential iron cover rate for women in reproductive age in Benin

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Abstract

Micronutrient deficiencies are known as main problem that affect women in reproductive age in developing countries. Food fortification is one of the strategies that has been successfully used to fight against such a plague. For technical reasons and better sustainability, the classical food fortification is progressively difficult in developing countries and food to food fortification is more and more used as alternative. *Moringa oleifea* and *Adansonia digitata* are two available species used for their nutritional proprieties. The present study aimed at (i) identifying the most appropriate food matrices candidates for food to food fortification, (ii) formulating adequate food to food fortification using moringa leaf powder and/or baobab fruit pulp for women in reproductive age and (iii) determining the contribution of the formulated food to iron daily need for women in reproductive age. The food vehicles candidate for food fortification were selected using their consumption frequencies. The fortification rate was defined according to local population practices and data from literature. Carbohydrates, fat, protein, iron, zinc and calcium contents were theoretically estimated using two methods mainly the manual method (including yield and retention factors) and a method using Nutrisurvey software 2007. The results showed that the fortification decreases but not significantly the macronutrients content of maize porridge while it increased the iron content from 3.90±1.1mg/100g (dw) to 8.91±1.0mg/100g in dual fortified maize porridge (Baobab fruit pulp and + moringa leaf powder) (p=0.01). The daily consumption level (667g/day) of dual fortified porridge by women in reproductive age would cover 52% of iron recommended intake for non-pregnant and non-lactating women, 60.61% of lactation women and 18.45% for pregnant women, the bioavailable quantity is probably lower. Moringa leaf powder (MLP) and baobab fruit pulp (BFP) could be used for successful food to food fortification and then as such deserve thorough investigation.

Keywords : dual fortification, micronutrient deficiencies, porridge,

Résumé

La carence en micronutriments reste un problème majeur des femmes en âge de procréer dans les pays en voie de développement. Plusieurs stratégies alimentaires dont la fortification alimentaire existent et sont utilisées pour combattre avec succès ce fléau. Pour des raisons techniques, la fortification classique est de plus en plus inefficace dans les pays en voie de développement car est reste moins durable dans le temps et elle laisse place donc à la fortification aliment par aliment qui est de plus en plus utilisée comme alternative. Par ailleurs, *Moringa oleifera* et Adansonia *digitata* sont deux ressources très utilisées par la population à cause de leurs valeurs nutritionnelles. L'objectif de la présente étude est de (i) identifier les matrices alimentaires candidates pour la fortification aliment par aliment, (ii) formuler des formules adéquates de fortification aliment par aliment en utilisant la poudre de feuille de moringa et/ou la pulpe du fruit de baobab pour les femmes en âge de procréer et (iii) d'évaluer la contribution des formules sur la couverture des besoins journaliers en fer des femmes en âge de procréer. Les matrices alimentaires sont choisies en utilisant comme critère leur fréquence de consommation. Le taux de fortification est déterminé à partir des résultats de revue de littérature et des pratiques traditionnelles des femmes. Les teneurs en glucide, lipide, protéine, fer, zinc et calcium des aliments fortifiés ont été estimées de façon théorique à l'aide d'une méthode manuelle intégrant les facteurs de rendement et de rétention et avec le logiciel Nutrisurvey 2007. Les teneurs en macronutriments de la bouillie de maïs ont diminué mais de façon non significative après fortification tandis que la teneur en fer augmenté de façon significative ($p=0.01<0.05$) dans la bouillie de maïs doublement fortifiée avec la poudre de feuille de moringa et la pulpe du fruit de baobab de 3,90±1,1mg/100g base sèche à 8,91±1,0mg/100g base sèche. De plus, une consommation journalière de 667g/jour de la bouillie de maïs doublement fortifiée pourrait couvrir 52% des besoins journaliers en fer des femmes en âge de procréer ni enceinte et ni allaitante, 60,61% des besoins journaliers en fer des femmes allaitantes et 18,45% des besoins journaliers en fer des femmes enceintes ; la quantité biodisponible étant probablement faible. La poudre de feuille de moringa et la pulpe du fruit de baobab pourraient être utilisées avec succès pour la fortification alimentaire par les aliments et donc mérite plus d'investigation.

Mots clés : bouillie, carence en micronutriment, double fortification

Introduction

In the developing countries, the micronutrients deficiencies represent a public health problem with physiological and economic consequences (Berger, 2003). The World Health Organization (WHO) estimates that more than 2 billion people are deficient in key vitamins and minerals, particularly vitamin A, iodine, iron and zinc and the most vulnerable groups to these deficiencies are pregnant and lactating women and young children (Das et al., 2013). Deficiencies of these micronutrients are estimated to affect

maternal mortality and impaired physical, mental and psychomotor development of its foetus, therefore, its affect people's life quality which can have an impact on productivity (Ahmed et al, 2016). In Benin, demographical survey revealed that 41% of women in reproductive age are anaemic (INSAE, 2013). For women of reproductive age, iron deficiency affected cognitive development of children and increase morbidity and mother mortality (Berger, 2003). Food fortification is one strategy that has been used effectively to prevent micronutrient deficiencies and has been practiced in developed countries and can be employed to supplement micronutrients to women food (Das et al., 2013). Because of difficulties of sustainable implementation in developing countries, food to food fortification is more and more used as alternative. Recent research projects showed the food and nutritional importance of forest food resources such as baobab (Chadare, 2010) and moringa leave (Zongo et al, 2013; Houndji, 2013). The pulp of baobab contain a carbohydrates (76.2 ± 1.0%), proteins (8.2 ± 0.1%), and low fats (0.3 ± 0.0%) (Osman, 2004). Abdullahi et al (2014) reported that the baobab fruit pulp contains high level of antioxidants, essential minerals especially calcium, potassium, iron, magnesium and vitamin C. According to Chadare (2010), the baobab pulp is known to be rich in vitamin C up to 360mg/100g dw. The leaves of *Moringa oleifera* have been reported to be a valuable source of macronutrient such as protein (17.01%) and carbohydrates (63.11%), crude fibre (7.09%), ash (7.93%) and micronutrient (Ca (1.91%), Fe (107.48±8.2) and Zn (60.06±0.3) (Ogbe and Affiku, 2011). Moringa leaves have been used to combat malnutrition, especially among infants and nursing mothers (Luqman et al., 2012). In the present study, these two food resources are considered as fortificants to be used in food to food fortification practices in order to improve cover rate of micronutrients especially iron for women of reproductive age.

1. Material and methods

➢ Study areas and field survey

This fieldwork was conducted in the three biogeographical zone of Benin: sudanian zone, sudano-guinean zone and guinean zone where moringa leaf powder and/or baobab fruit pulp are integrated in the food habit of populations. Two municipalities were selected in each biogeographical zone and two villages per municipality. The sample size was determined according to Dagnelie (1998) formula ($Ni=(4Pi(1-Pi))/d^2$) with Pi the proportion of consumers of baobab fruit pulp and/or moringa powder of leaf among 50 randomly checked people and d the margin error fixed at 0.07. Inventory and consumption frequency of food matrices that used moringa leaf powder and/or baobab fruit pulp as ingredients, proportion of moringa and baobab traditionally added by women of reproductive age were recorded.

➢ Food matrices selection and food fortification

The field survey provides a large number of food matrices. The food matrices selection was performed using consumption frequency and proportion of women in reproductive age who consume each food

matrice. A score of consumption frequency (SCF) was then defined and computed as below for each food matrice.

$$\mathbf{SCF} = (\mathbf{consumption\ frequency} * \mathbf{proportion\ that\ consume\ food\ matrice})$$

With SCF= Score of consumption frequency

The food matrices that have the highest score of consumption frequency were selected as potential candidates for food to food fortification. The fortification rate was determined using local population practices relative to the amount of moringa leaf powder and/or baobab fruit pulp daily consumed by women in reproductive age and literature data.

- **Food to food fortification assays**

A dual food to food fortification practice was performed. Traditional food practices and literature revealed mostly fortification with moringa leaf powder only. Fortification with baobab fruit pulp was mostly used for technological purposes. The fortification rate reported in literature were very variable. In the present study, three types of fortification are used:

(i) fortification of maize porridge with only Moringa leaf powder at a forfication rate of 9.09% (wb);

(ii) fortification of maize porridge with baobab fruit pulp only at a fortification rate of 9.09% (wb);

(ii) fortification of maize porridge with a precise combination of baobab fruit pulp and moringa leaf powder at a global fortification rate of 13.04% (wb).

- **Theoretical assessment of physico-chemical characteristics of unfortified and fortified food matrices**

Macronutrients and micronutrients content were assessed using calculation procedures including the use of yield and retention factors (Vásquez-Caicedo et al., 2008) (method 1) and Nutrisurvey 2007 software (method 2). In the first method, the yield factor was applied at recipe level (macronutrient) and the retention factors at ingredient level especially for minerals content of ingredients. In the second method, the nutritional value of each ingredient was included in food database of the Nutrisurvey software and the amount of ingredient in recipe was indicated. The nutritional value of the recipe nutritional value was estimated automatically by the software. The mean values were calculated with data provided by the two methods.

- **Contribution of fortified food to iron recommended daily intakes of women in reproductive age**

The iron recommended daily intake of female, lactating women and pregnant women from Rose et al (2011) were used. The consumption level of the fortified food daily consumed by women in reproductive age was used to estimate the iron recommended intakes cover rate through formula below

$$\mathbf{Cover\ rate}\ (\%) = \frac{\mathbf{Iron\ in\ the\ fortified\ food\ daily\ consumed\ by\ women}}{\mathbf{Iron\ recommended\ daily\ intake}} \times \mathbf{100}$$

- **Statistical analysis**

The statistical analysis was performed using Minitab 16 software. Analyse of variance (ANOVA) followed by Turkey test were performed to assess difference between fortified and unfortified food in term of their macronutrient and micronutrient contents.

2. Results

Through field survey, several food matrices were identified, the one with the highest score of consumption frequency was selected, food to food fortification assays were performed followed by a theoretical assessment of nutritional value.

2.1. Food matrices used by women in reproductive age and their score of consumption frequency

The field survey showed that many food matrices used moringa leaf powder and/or baobab fruit pulp and these matrices vary from one biogeographical zone to another. Table 1 shows the score consumption frequency of different porridges (maize, sorghum and soya) and soups (groundnut soup, palm nut soup, tomato soup and koata soup) consumed by women in reproductive age in the three biogeographical zones of Benin. In all biogeographical zones, the maize porridge has the highest score 131 in the Guinnean zone, 340 in the Sudanian-Guinean zone and 295 in the Sudanian zone respectively. It appears obvious that maize porridge will be used as food matrices for food to food fortification assays with moringa leaf powder and/or baobab fruit pulp as forticants.

Table 1: Score of consumption frequency of food matrices used by women in reproductive age per biogeographical zone

	Guinean	Sudano-Guinnean	Sudanian
Maize porridge	295	340	131
Sorghum porridge	125	37	21
Soya porridge	21	13	-
Grundnut soup	18	129	-
Koata soup	41	-	-
Tomato soup	-	68	3
Palm nut soup	-	-	125

-: Not determinable because it was not consumed in respectively biogeographical zone

2.2. Nutritional value of the fortified and unfortified maize porridge for women

The macronutrients contents of the fortified and unfortified maize porridge using method 1(manual method using yield and retention factors) are higher than those using method 2 (Nutrisurvey software). The mean of carbohydrates content of maize porridge decreased after dual fortification from 120.37±64.7g/100g (dw) to 106.03±55.1g/100g (dw). However, the protein mean content increased in maize porridge fortified with MLP (from 16.51±10.5g/100g (dw) to 17.28±9.4 g/100g (dw). The fat mean content increased also in maize porridge fortified with MLP (from 7.13±5.0g/100g (dw) to 7.17±4.5g/100g (dw). Generally, no significant difference was found between unfortified porridge and fortified porridge ($p>0.05$) (Table 2).

Table 2: Macronutrient content of unfortified and fortified maize porridge (g/100g dw)

Fortified and unfortified food	Methods	Carbohydrate (g/100g dw)	Protein (g/100g dw)	Fat (g/100g dw)
Maize porridge	Method 1	166.14	23.92	10.66
	Method 2	74.60	9.10	3.60
	Mean	**120.37±64.7**	**16.51±10.5**	**7.13±5.0**
Maize porridge fortified with BPF and MLP	Method 1	144.96	23.03	9.98
	Method 2	67.10	10.40	4.00
	Mean	**106.03±55.1**	**16.71±8.9**	**6.99±4.2**
Maize porridge fortified with BPF	Method 1	157.02	22.06	9.95
	Method 2	74.60	8.70	3.60
	Mean	**115.81±58.3**	**15.38±9.4**	**6.78±4.5**
Maize porridge fortified with MLP	Method 1	149.53	23.96	10.34
	Method 2	64.10	10.60	4.00
	Mean	**106.81±60.4**	**17.28±9.4**	**7.17±4.5**

BFP: Baobab Fruit Pulp **MLP**: Moringa Leaf Powder

Method 1: Manual method using yield and retention factors **Method 2**: Nutrisurvey software

Table 3 presents micronutrient content of fortified and unfortified maize porridge. Generally, it was noticed that the estimation of micronutrient value using method 2 (Nutrisurvey software) was lower than those using method 1 (manual method using yield and retention factors). The mean of iron content increased significantly on dual fortified maize porridge from 3.90±1.1mg/100g dw to 8.91±1.0mg/100g dw ($p=0.01$). The mean of calcium content increased from 72.00±00mg/100g dw to 220.67±63.7mg/100g while the mean of zinc content increased from 0.84±0.9mg/100g dw to 2.55±0.8mg/100g dw on dual fortified maize porridge.

Table 3: Mineral content of unfortified and fortified maize porridge (mg/100g dw)

Fortified and unfortified food	Methods	Iron (mg/100g dw)	Calcium (mg/100g dw)	Zinc (mg/100g dw)
Maize porridge	Method 1	3.10	19.00	1.47
	Method 2	4.70	125.00	0.20
	Means	**3.90±1.1**	**72.00±75.0**	**0.84±0.9**

Maize porridge fortified with BFP and MLP	Method 1	8.23	175.64	3.09
	Method 2	9.60	265.70	2.00
	Means	**8.91±1.0**	**220.67±63.7**	**2.55±0.8**
Maize porridge fortified with BFP	Method 1	3.22	47.30	1.50
	Method 2	4.60	142.70	0.40
	Means	**3.91±1.0**	**95.00±67.5**	**0.95±0.8**
Maize porridge fortified with MLP	Method 1	8.17	161.49	3.08
	Method 2	9.60	256.9	2.00
	Means	**8.88±1.0**	**209.20±67.5**	**2.54±0.8**

BFP: Baobab Fruit Pulp **MLP**: Moringa Leaf Powder

Method 1: Manual method using yield and retention factors **Method 2**: Nutrisurvey software

- **Contribution of maize porridge fortified to iron recommended intakes for women in reproductive age**

Table 4 shows the contribution of fortified maize porridge to iron recommended daily intakes for women in reproductive age. The consumption of 667.63g/d of dual fortified maize porridge and maize porridge fortified with MLP covers respectively 52.38% and 60.61% of iron recommended daily intake for lactating and non-pregnant and non-lactating women and 18.45% of iron intakes was covered for pregnant women using dual fortified maize porridge and maize porridge fortified with MLP. The cover rate mentioned are a maximum. In practice, part of the micronutrients content will be bioavailable. As such, the actual cover rate after absorption is probably lower.

Table 4: Contribution of fortified maize porridge to iron recommended daily intakes for women in reproductive age iron recommended daily intakes

	Women targeted	Iron content (mg/100g dw)	Iron on porridge consume (mg/d)	Recommended intakes (mg/d)	Covers rate (%)
Unfortified maize porridge	Lactation	3.90	1.86	7.00	26.52
	Pregnancy	3.90	1.86	23.00	8.07
	Female	3.90	1.86	8.10	22.92
Maize porridge fortified (with BPF and MLP	Lactation	8.91	4.24	7.00	60.61
	Pregnancy	8.91	4.24	23.00	18.45
	Female	8.91	4.24	8.10	52.38
Maize porridge fortified with BPF	Lactation	3.91	1.86	7.00	26.59
	Pregnancy	3.91	1.86	23.00	8.09
	Female	3.91	1.86	8.10	22.98
Maize porridge fortified with MLP	Lactation	8.88	4.23	7.00	60.40
	Pregnancy	8.88	4.23	23.00	18.38
	Female	8.88	4.23	8.10	52.20

3. Discussion

Food to food fortification appears to be more adequate in developing countries provided that the right fortification rate is used for a selected target group and that food fortificants deliver needed quantity and quality of micronutrients. By adding the food fortificants to the food matrices, it is likely that this affects the whole composition of the fortified foods. Indeed, according to theoretical estimations performed in the present study, moringa leaf powder and baobab fruit pulp improve the micronutrients content of maize porridge after fortification. As such, a decrease of carbohydrates of maize porridge after fortification was noticed as similarly reported by Adejuyitan et al (2012) by fortifying ogi powder with baobab fruit pulp and Abioye et al (2015) in ogi powder fortified with moringa leaf powder. The increase of iron and calcium content of maize porridge fortified with moringa leaf powder and dual fortified with MLP and BFP can be attributed to the high iron and calcium content of moringa leaf powder. As reported by Kayalto et al (2015), the moringa leaf powder contains 53.75mg/100g dw of iron and 1443.90mg/100g dw of Calcium while baobab fruit pulp contains 4.30mg/100g dw of iron and 1.70mg/100g dw of Calcium (Chadare, 2010). As such, dual food to food fortification is a potential way to upgrade micronutrients content of food and deliver nutritious foods to target populations.

Iron deficiency is the mostly worldwide deficiency found in the world. By practising it on the right way through a good approach of food to food fortification, such a deficiency may be reduced in many developing countries. Indeed, the cover rate found in this study were up to 60% which is interesting. However, there may be a discrepancy between micronutrient content and their bioavailability. Due to its high vitamin C content, baobab pulp can be seen as acidulate that may have a positive effect on digestibility of micronutrients. As such, food to food fortification is a potential way to deliver micronutrients to target populations. These aspects need further investigation and would provide data to adjust the fortification rate. Apart from the previous aspect, theoretical estimation of nutritional value is common practice and offers a rough idea about the nutrient content of the food and is cheap. However, it is not always as precise as laboratory analyses which are very costly. Indeed, in the present study, the two methods used provide different theoretical values for the same foods. This may be due to the fact that the manual calculation method includes yield conversion factors (Vásquez-Caicedo et al., 2008) and provide higher values than the one provided by the software (Nutrisurvey software 2007). This conversion factors is a necessary because, the yield factors was used to integrated the undergoing changes of raw foods weight after preparation or any other treatment (Vásquez-Caicedo et al, 2008). According to Bognar (2002), the preparation of food by heat processing in particular by cooking may lead to essential changes in weight and nutrient content. The software is used mainly for rapid estimation of food found during field survey. It appears that the best to do is to proceed with laboratory analyses whenever possible to have more precise values about food nutrients content.

Conclusion

Maize porridge is the food matrices with the highest score of consumption frequency. The fortification using moringa leaf powder and or baobab fruit pulp as fortificant significantly increased mineral content of food matrices used (maize porridge) especially iron and calcium content. It good to mention that theoretical assessment of nutritional value is different with laboratory analysis. Investigation need to be performed at lab scale to assess nutritional value of fortified food and their acceptability.

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Selected references

ABIONA, D. L., ADEDAPO, Z. & SULEIMAN, M. K. 2015. Proximate Analysis, Phytochemical Screening and Antimicrobial Activity of Baobab (Adansonia digitata) Leaves. *IOSR Journal of Applied Chemistry,* 8**,** 60-65.

ADAM, Y. O. 2017. Consumer's preferences and factors affecting the urban demand for Baobab (*Adansonia digitata L.*) fruits in Sudan. *Forestry Ideas,* 23**,** 103-112.

ALHASSAN, A. J., MUHAMMAD, I. U., JARUMI, I. K. & WUDIL, A. M. 2016. Evaluation of Anti-hyperlipidemic potentials of Aqueous fruit pulp extract of *Adansonia digitata* in experimental rats. *European Scientific Journal,* 12**,** 298-308.

AMUGSI, D. A., DIMBUENE, Z. T., MBERU, B., MUTHURI, S. & EZEH, A. C. 2017. Prevalence and time trends in overweight and obesity among urban women: an analysis of demographic and health surveys data from 24 African countries, 1991–2014.

ASSOGBADJO, A. E., CHADARE, F. J., KAKAÏ, R. G., FANDOHAN, B. & BAIDU-FORSON, J. J. 2012. Variation in biochemical composition of baobab (*Adansonia digitata*) pulp, leaves and seeds in relation to soil types and tree provenances. *Agriculture, Ecosystems and Environment,* 157**,** 94-99.

BERGER, J. 2003. Enrichissement des aliments en micronutriments: élément d'une stratégie intégrée de lutte contre les carences en micronutriments, en particulier en fer, dans les pays en développement 563-576.

BHAT, F. Z., MORTONA, D. J., MASONA, S., BEKHITB, A. A. E.-D. & BHATC, H. F. 2017. Obesity and neurological disorders: Dietary perspective of a global menace. *Critical Reviews in Food Science Nutrition*.

BJORNTORP, P. 2002. Definition and Classification of Obesity. *In:* FAIRBURN, C. G. & BROWNELL, K. D. (eds.) *Eating Disorders and Obesity: A comprenhensive handbook.* 2 ed. New York (USA): The Guilford Press.

CHADARE, F. J. 2010. Baobab (Adansonia digitata L.) foods from Benin : composition, processing and quality. *Thesis submitted in the fulfilment of the requirements for the degree of doctor at Wageningen University, Graduate School VLAG (Voeding, Levensmiddelentechnologie, Agrobiotechnologie en Gezondheid)***,** 186.

CHADARE, F. J., HOUNHOUIGAN, J. D., LINNEMANN, A. R., NOUT, M. J. R. & BOEKEL, M. A. J. S. V. 2008. Indigenous Knowledge and Processing of Adansonia Digitata L. Food Products in Benin. *Ecology of Food and Nutrition,* 47**,** 338-362.

DAGOGO-JACK, S. 2017. Primary Prevention of Type 2 Diabetes: An Imperative for Developing Countries. *Diabetes Mellitus in Developing Countries and Underserved Communities.*

DAS, J. K., SALAM, R. A., R., K. & A., B. Z. 2013. Micronutrient fortification of food and its impact on woman and child health: a systematic review. *systematic review,* 2**,** 2-24.

DE CALUWÉ, E., HALAMOVÁ, K. & VAN DAMME, P. 2010. Adansonia digitata L. – A review of traditional uses, phytochemistry and pharmacology. *Africa Focus,* 23**,** 11-51.

EAS 2000. Fruits, vegetables and derived products - -Sampling and methods of test: Part 5.

EL-NAGERABI, S. A. F., ELSHAFIE, A. E., ALKHANJARI, S. S., AL-BAHRY, S. N. & ELAMIN, M. R. 2013. The Potential of Baobab (Adansonia digitata L.) Extracts as Biocontrol on the Growth and Aflatoxin Production by Aspergillus flavus and A. parasiticus *Journal of Food Research,* ISSN 1927-0887 E-ISSN 1927-0895 93-103.

ELLIOTT, R. & ONG, T. J. 2002. Nutritional genomics. *BMJ: British Medecinal Journal,* 324**,** 1438–1442.

GADOUR, O. M., KHIDIR, B. H., ADAM, I. & GASIM, I. G. 2017. Effects of a powder of the fruit of *Adansonia digitata* (Tabaldia, Gongolase, or baobab tree) on serum lipids. *Journal of Herbal Medecine*.

GRUENWALD, J. 2009. Novel botanical ingredients for beverages. *Clinics in Dermatology* 27**,** 210–216.

GURASHI, N. A., KORDOFANI, M. A. Y., ABDELGADIR, K. A. & SALIH, A. A. M. 2016. Variation in Chemical Composition of Baobab (Adansonia digitata L) fruits pulp in relation to fruit shape types and locations. *International Journal of Scientific Engineering and Applied Science* 2.

HOSSEINI, B., SAEDISOMEOLIA, A. & ALLMAN-FARINELLI, M. 2016. Association Between Antioxidant Intake/Status and Obesity: a Systematic Review of Observational Studies. *Biological Trace Element Research*.

ISO 2003. Fruit and vegetable products - Determination of soluble solids - Refractometric method.

KABORÉ, D., SAWADOGO-LINGANI, H., DIAWARA, B., COMPAORÉ, C. S., DICKO, M. H. & JAKOBSEN, M. 2011. A review of baobab (Adansonia digitata) products: Effect of processing techniques, medicinal properties and uses *African Journal of Food Science,* 5**,** 833-844.

LI, X.-N., SUN, J., SHI, H., YU, L., RIDGE, C. D., MAZZOLA, E. P., OKUNJI, C., IWU, M. M., MICHEL, T. K. & CHEN, P. 2017. Profiling hydroxycinnamic acid glycosides, iridoid glycosides, and phenylethanoid glycosides in baobab fruit pulp (Adansonia digitata). *Food Research International*.

LUQMAN, S., SRIVASTAVA S., KUMAR R., MAURYA K. A. & DEBABRATA C. 2012. Experimental Assessment of Moringa oleifera Leaf and Fruit for Its Antistress, Antioxidant, and Scavenging Potential Using In Vitro and In Vivo Assays. *Hindawi Publishing Corporation* 12 pages.

MARSHALL, L. J., HOLMES, M. J. & TEMBO, D. T. 2017. Effect of thermal treatment and storage on bioactive compounds, organic acids and antioxidant activity of baobab fruit (Adansonia digitata) pulp from Malawi. *Journal of Food Composition and Analysis,* 58**,** 40-51.

MUHAMMAD, I. U., JARUMI, I. K., ALHASSAN, A. J., WUDIL, A. M. & DANGAMBO, M. A. 2016. Acute Toxicity and Hypoglycemic Activity of Aqueous Fruit Pulp Extract of Adansonia digitata L. (Afpead) on Alloxan Induced Diabetic Rats *Journal of Advances in Medical and Pharmaceutical Sciences,* 6**,** 1-6.

OGBAGA, C. C., NURUDDEEN, F. A., ALONGE, O. O. & NWAGBARA, O. F. 2017. Phytochemical, Elemental and Proximate Analyses of Stored, Sun-Dried and Shade Dried Baobab (Adansonia Digitata) Leaves.

OGBE, A. O. & AFFIKU, J. P. 2011. Proximate study, mineral and anti-nutrient composition of Moringa oleifera leaves harvested from lafia, nigeria: Potential benefits in poultry nutrition and health. *Journal of Microbiology, Biotechnology and Food Sciences,* 1**,** 296-308.

OSMAN, M. A. 2004. Chemical and Nutrient Analysis of Baobab (Adansonia digitata) Fruit and Seed Protein Solubility. *Plant Foods for Human Nutrition* 59**,** 29–33.

RAO, J. M. & TIWARI, A. K. 2002. Diabetes mellitus and multiple therapeutic approaches of phytochemicals: Present status and future prospects. *Current Science,* 83.

RENAUD, B., BENJAMIN, Y., IBRAHIMA, C., DIDIER, M., MAX, R. & PASCAL, D. 2013. Biochemical and nutritional properties of baobab pulp from endemic species of Madagascar and the African mainland. *African Journal of Agricultural Research,* 8**,** 6046-6054.

SARAVANARAJ, M., MUTHUSAMY, P., RADHA, R. & JERAD SURESH, A. 2017. Anti-diabetic effect of the ethanolic extract of dried fruits of *Adansonia digitata Linn*. *World Journal of Pharmacy and Pharmaceutical Sciences,* 6**,** 1597-1605.

UJJALIYA, N., DASH, S. & JAIN, S. K. 2018. A REVIEW ON NUTRACEUTICALS IN AYURVEDA. *World Journal of Pharmacy and Pharmaceutical Sciences,* 7**,** 277-281.

VÁSQUEZ-CAICEDO, A. L., BELL, S. & HARTMANN, B. 2008. Report on collection of rules on use of recipe calculation procedures including the use of yield and retention factors for imputing nutrient values for composite foods. *European Food Information Ressource Network*.

VILJOEN, A. M., VERMAAK, I. & KAMATOU, G. P. P. 2011. An updated review of Adansonia digitata: A commercially important African tree. *South African Journal of Botany,* 77**,** 908-919.

WRICK, K. L. 2005. The impact of regulations on the business of Nutraceutical in the United States: Yesterday, Today and Tomorrow. *In:* HASLER, C. M. (ed.) *Regulations of Functional Foods and Nutraceuticals: A global perspective.* Iowa 50014, USA: Blackwell Publishing.

ZEITOUN, H., KHOURY, R. E., BEYROUTHY, M. E., SALAMEH, D. & LTEIF, R. 2016. Phytochemicals Screening and Anti-tyrosinase Activity of Senegalese Herbal Extracts. *International Journal of Innovative Research in Science, Engineering and Technology,* 5.

Abstract submitted by the MSc Student 2

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Effect of different pasteurization schemes on baobab nectar quality

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Abstract

The baobab is a multi-purpose tree which is use in many countries for its nutritional and medicinal properties. Due to its sensorial and nutritional properties, it constitutes an opportunity for some processing units to valorize it through the processing of the pulp; one of its derived products is the nectar. The stabilization of this product involves thermal treatments. The aim of this study was to assess the effectiveness of different thermal treatments scales on the microbiological, physicochemical and organoleptic qualities of the baobab nectar. The baobab technological diagram used in selected processing (two thermal treatments) units was documented and realized. For the assessment of different pasteurization scales, a modified technology with one heating was used; the used scales were: (T1) 65°C for 15 minutes, (T2) 75°C for 10 minutes and (T3) 80°C for 5 minutes. A preference test was performed to find out the preference of consumers for products with two or one thermal treatments. The parameters such as pH, brix value, color and the load of lactic acid bacteria and yeasts and moulds were determined on the freshly produced pasteurized nectar and those stored. The results showed that panelists have a preference for nectar produced with one thermal treatment. There is no significant difference in pH and color whatever the pasteurization scale applied. Lactic acid bacteria were absent in freshly and pasteurized baobab nectar stored for one month at 30°C. All baobab nectars have mould and yeast load in accordance with the standards. A storage experiment integrating processors practices and modified techniques are necessary for technological optimization that promotes nutrients retention and safety.

Keywords: Baobab, color, lactic acid bacteria, nectar, organoleptic characteristics.

Résumé

Le baobab est un arbre à usages multiples qui est utilisé dans de nombreux pays pour ses propriétés nutritionnelles et médicinales. A cause de ses propriétés sensorielles et nutritionnelles, il constitue une opportunité pour certaines unités de transformation qui le valorisent à travers la transformation de la pulpe; l'un de ses produits dérivés est le nectar. La stabilisation de ce produit implique des traitements thermiques**.** L'objectif de cette étude est d'évaluer l'efficacité de différents barèmes de traitements thermiques sur les qualités microbiologiques, physico-chimiques et organoleptiques du nectar de baobab. Le diagramme technologique du nectar de baobab utilisé dans les unités de transformation sélectionnées (deux traitements thermiques) a été documenté et réalisé. Pour l'évaluation des différents barèmes de pasteurisation, une technologie modifiée avec un traitement thermique a été utilisée; les barèmes utilisés étaient: (T1) 65°C pendant 15 minutes, (T2) 75°C pendant 10 minutes et (T3) 80°C pendant 5 minutes. Un test de préférence a été effectué pour déterminer la préférence des consommateurs pour les produits avec un ou deux traitements thermiques. Les paramètres tels que le pH, le degré Brix, la couleur et la charge des bactéries lactiques et des levures et moisissures ont été déterminés sur le nectar pasteurisé

fraîchement produit et ceux stockés. Les résultats ont montré que les panélistes ont une préférence pour le nectar produit avec la technologie modifiée d'un traitement thermique. Il n'y a pas de différence significative de pH et de couleur, quel que soit le barème de pasteurisation appliqué. Les bactéries lactiques sont absentes dans le nectar de baobab pasteurisé fraîchement et conservé pendant un mois à 30°C. Tous les nectars de baobab ont une charge en levures et moisissures conforme aux normes. Une expérience de stockage intégrant les pratiques des transformateurs et les techniques modifiées est nécessaire pour l'optimisation technologique qui favorise la rétention des nutriments et la sécurité sanitaire du produit.

Mots clés : Baobab, couleur, bactéries lactiques, nectar, caractéristiques nutritionnelles

Introduction

The baobab (*Adansonia digitata*) tree is commonly encountered under tropical climatic conditions (Akubor, 2017). The consumption of its fruits improves the nutritional quality of African population diet (Parkouda et *al*., 2007). In West Africa and especially in Benin, baobab (bark, leaves, fruits, seeds) is widely used by local populations for food, therapeutic and economic and/or sociocultural reasons (Assogbadjo et al., 2005; Kouyaté et al., 2011). In Benin, baobab fruit pulp is traditionally valued in the form of beverages (juice and nectars), fermented dough (commonly called Mutchayan in Otamari language), porridge as well as lollipops (Chadare et al., 2008). A very popular and widespread product is the baobab nectar, also called in Senegal "Bouyé juice" (Cissé et al., 2009). Most of those fresh nectars were not stabilized and therefore have limited shelf life. Nowadays, more and more pasteurized baobab nectars are available on Beninese markets, especially in large cities. However, the quality of these commercialized nectars is still unknown. In Benin, the color and viscosity of baobab nectars produced in Benin suggest that applied heat treatments are severe. Such an observation was confirmed by the investigations of Gbaguidi et al. (2017) during pineapple juice processing. Knowing that baobab is rich in heat sensitive nutrients such as vitamin C, severe heat treatments could significantly reduce the nutritional quality of baobab nectars. Consequently, this study aimed to determine the most appropriate conditions for baobab nectar pasteurization in Benin.

Material and Methods

Material

The baobab pulp used for production was purchased at Dantokpa market in Cotonou.

Methods

Experimental design

Six commonly visited supermarkets of Cotonou, the economic capitale of Benin, were screened to identify the commercialized baobab nectar brands. The processing diagram of the three most common brands encountered was determined through a process follow-up study. Productions were followed per processing unit to identify the flow diagrams as well as the conditions applied for implementing each unit operation. Based on the flow diagrams used by the processing units, a modified flow diagram was suggested for obtaining a fluid Baobab nectar in the laboratory conditions. This diagram was tested measuring pH, brix value, color, load on lactic acid bacteria and yeasts.

Using the modified flow diagram, three pasteurization schemes namely (T1):65°C-15 minutes, (T2):75°C-10 minutes, and (T3):80°C-5 minutes were tested. The suggested schemes were compared measuring pH, brix value, color, load on lactic acid bacteria and yeasts.

The most promising product was compared with the conventional product obtained from the processing unit diagram.

A storage test was performed by assessing the physico-chemical (pH, brix value and color) and microbial (lactic acid bacteria and yeast counts) characteristics of the nectars after production and after 30 days of storage at 30°C. All analyses and productions were performed in triplicate.

Analyses

Nectar pH was measured with a pH meter according to ISO1842 (EAS, 2000) method. Nectar brix value was determined using an ATAGO digital refractometer according to ISO 2173 (ISO, 2003). Color of baobab nectar was determined using the CR410 Konica Minolta colorimeter to assess *L**, *a**, *b** indexes. For each sample, these parameters were measured in duplicate.

Yeasts counts were assessed on sabouraud agar supplemented with chloramphenicol agar incubated at 25°C for 5 days (ISO 21527-2: 2008). Lactic acid bacteria were enumerated on de Man Rogosa and Sharpe medium after incubated at 30°C for 3 days (ISO 15214: 1998).

An analysis of variance followed by a Dunett test helped comparing the baobab nectar characteristics during storage.

Preference test was conducted with 37 baobab nectar common consumers selected as panelists. They were assigned to compare the pasteurized nectar prepared according to the processing unit' diagram and pasteurized nectar according to the modified diagram.

Data were analyzed using the two-tailed binomial test (Watts et al., 1981).

Results

Production of pasteurized baobab nectar according to processors techniques

Pasteurized baobab nectar is usually made from pulp. First, the processors mixed the baobab pulp with water and homogenized. Next, the mixture is sieved to remove the wastes (baobab fibers and seed). To the sieved mash, sugar is added with more water and the mix is cooked for about 30 minutes. At the end of the heating, the nectar is packed in 25 cl glass bottles initially well cleaned. The bottled nectar is pasteurized at 90°C for 25 minutes. The flow diagram for the processing of pasteurized baobab nectar is shown in figure 1.

Production of baobab nectar using the modified technique in the laboratory

Baobab nectar was made from baobab fruit pulp, hot water and sugar using the below diagram presented in figure 2. The baobab pulp was sieved to remove some wastes, mixed with hot water at 60°C and homogenised. The obtained mix is packed in sterilezed or initially well cleaned bottles (25cl) and pasteurized at 65°C-15 minutes, 75°C-10 minutes and 80°C- 5 minutes.

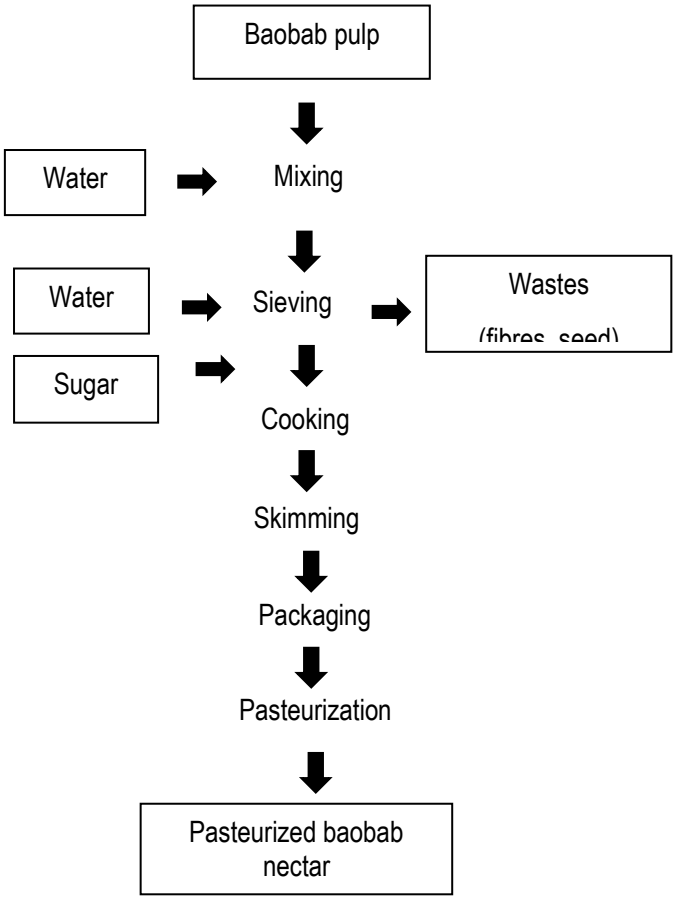

Figure 1: Processing diagram of baobab nectar by surveyed processors

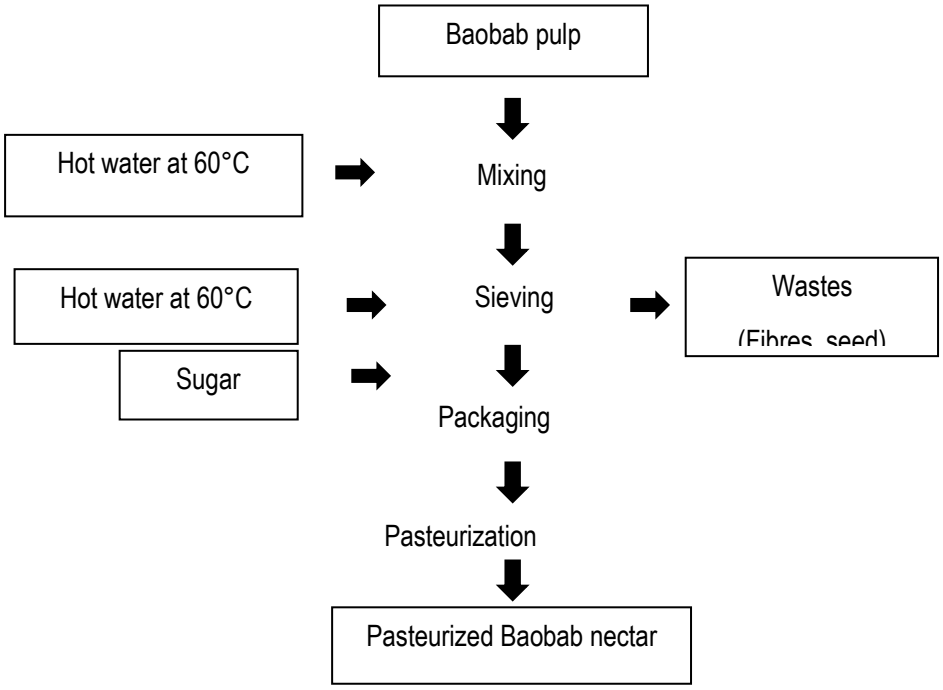

Figure 2: Processing diagram of pasteurized baobab nectar using the modified technique (without cooking)

Preference of uncooked baobab nectar before pasteurization

The preference test performed with 37 randomly selected panelists revealed that 62.2% of the panelists preferred the pasteurized baobab nectar without cooking (one thermal treatment) while 37.8% preferred the pasteurized nectar with cooking (Table 1)

Table 1 : Preference of baobab nectar

Prefered product	Number of panelist	Criteria	Number of tasters per criterion chosen [number (%)]
Pasteurized baobab nectar without cooking	23	Acid taste	52.1
		Sweet taste	65.2
		Texture	43.4
		Aroma	39.1
		Global preference	62,2
Pasteurized baobab nectar with cooking	14	Acid taste	50
		Sweet taste	42.8
		Texture	50
		Aroma	35.7
		Global preference	37,8

Effect of pasteurization on the physico-chemical characteristics of pasteurized baobab nectar

Table 2 shows the physico-chemical characteristics in terms of pH, Brix alue and colour, of baobab nectars according to different pasteurization scales. In general, the characteristics do not vary from one pasteurization scale to another. More specifically, pH values are at about 3 while brix values ranges from 12.97 to 13.15. The color parameters remained also quite stable.

Table 2: Effect of pasteurization on the physico-chemical characteristics of baobab nectar

Treatment	pH	Brix value	L*	a*	b*	ΔE*
T1 (65°C-15 min)	3.15±0.15 a	13.15±0 .02c	49.31±0 .46a	9.13±0, 35a	18.90±0 .97a	48.71±0 .54a
T2 (75°C-10min)	3.01±0.01 a	13.01±0 .03b	49.87±0 .27a	9.16±0, 12a	19.41±0 .17a	48.69±0 .17a
T3 (80°C-05min)	3.10±0.03 a	12.97±0 .04a	49.63±0 .31a	8.86±0, 24a	18.88±0 .24a	48.20±0 .41a

In each column, the same letters indicate they are not significantly different at 5%

L = lightness; a = redness; b = yellowness

Effect of pasteurization on microbiological characteristics of baobab nectar

Table 3 shows the average microbial load of the pasteurized baobab nectar. Lactic acid bacteria are absent whatever the pasteurization scale applied. The microbial load of yeast and moulds contained in the baobab nectar pasteurized at 65°C is 2.25 log10 CFU/g, while those of nectar pasteurized at 75°C and 80°C are < 1 log10 CFU/g. The higher the pasteurization temperature, the lower the yeast and mould load.

Table 3: Microbiological characteristics of pasteurised baobab nectar

Treatment	Shelf life (days)	Lactic acid bacteria (log_{10}UFC/g)	Yeast and moulds (log_{10} UFC/g)
T1 (65ºC- 15min)	0	0	2.25
	30	0	2.46
T2 (75ºC- 10min)	0	0	<1
	30	0	2.01
T3 (80ºC- 5min)	0	0	<1
	30	0	1.59

Ability to the preservation of the pasteurized baobab nectar

Table 4 shows the pH and the brix value values of the pasteurized baobab nectar stored for 30 days. No significant changes were observed between pH values of freshly pasteurized nectar and the samples (65°C and 80°C) and the ones stored for one month at room temperature.

The brix value of pasteurized baobab nectar irrespective of the pasteurization scale decreased during storage while color parameters remained quite stable.

Table 4: Effect of storage time on the physico-chemical characteristics of baobab nectar

Treatment	Time	Physico-chemical characteristics					
		pH	Brix value	L*	a*	b*	ΔE*
T1 (65°C-15min)	0	3.15±0.15	13.15±0.02	49.31±0.46	9.13±0.35	18.90±0.97	48.71±0.54
	30	3.18±0.01	12.96±0.03	49.11±0.03	9.55±0.31	18.40±0.28	48.67±0.38
		ns	***	ns	ns	ns	ns
T2 (75°C-10min)	0	3.01±0.01	13.01±0.03	49.87±0.27	9.16±0.12	19.41±0.17	48.69±0.17
	30	3.17±0.00	12.86±0.05	49.16±0.18	9.47±0.03	18.80±0.17	47.86±0.23
		***	ns	ns	ns	ns	**
T3 (80°C-5min)	0	3.10±0.03	12.97±0.04	49.63±0.31	8.86±0.24	18.88±0.50	48.20±0.41
	30	3.02±0.02	12 .53±0.02	49.52±0.12	9.92±0.20	19.90±0.02	48.64±0.15
		ns	***	ns	ns	ns	ns

ns: not significant; ***: significant at 1%; **: significant at 5%

L = lightness; a = redness; b = yellowness

Discussion

To reduce microbial load, the processors apply several thermal treatments which can also reduce nutritional quality of baobab nectar. This study show that the cooking has no influence on the organoleptic characteristics. The effect of pasteurization treatment on pH is not significant at the 5% threshold. Indeed, the parameters measured (pH, Brix value, color) are more intrinsic to the nectar whatever the pasteurization used. Some differences may be noticed during storage according to pasteurization scales. The low pH (3.15-3.18) of baobab nectar is favorable to a good preservation. Similar pH values were found in nectar of Parkia pulp (pH=3) (Ouattara, 2011). Chadare et al., (2017) reported that storage at 30°C for one day of non-pasteurized baobab milk nectar induced a significant decrease in pH value**.** The thermal treatment applied in the nectar under investigation may hinder any change in pH value. However, other changes may occur during storage. Indeed, baobab nectar stored at 4°C for 11 days lost 35% of its total sugar content (Cisse *et al.*, 2009). The same tendency is observed in the present study where the brix value of baobab nectar decrease after only one month of storage. As such, a longer storage period would induce a greater decrease. Brix value is an expression of total soluble solids content which includes also sugars. More precise estimation would include measurement of total or individual sugar.

The limit for yeasts and moulds in nectars according to standards is 30 CFU/g (Kenya Standard, 2016). Irrespective of the pasteurization scale, the produced nectars are in accordance with the standard. Indeed, yeast and moulds can grow at temperature range from 0°C to 60°C with a water activity between 0.7 and 0.8 (Alborch *et al.*, 1995). The presence of yeast and moulds in baobab nectar can be explained by their growth in baobab pulp if it's exposed to humidity. On local market and in local processing unit, it is sometimes hard to fully preserve raw material against humidity as mentioned for pulp of *Parkia biglobosa* used to prepare some nectar (Ouattara, 2011). This suggests that the practices of good handling of raw material and good manufacturing practices would help to prevent presence of some microorganisms. In fact, at pH lower than 4.5, very limited pathogenic microorganisms can grow except the acidophilic ones (Davidson and Critzer, 2012). As such, distribution temperatures, if not too high may keep for a reasonable time the product with low microbial load if there is no cross contamination during production, packaging and distribution (Chadare et al., 2017).

Conclusion

Practicing two or one thermal processing does not affect the physico-chemical characteristics of pasteurized baobab nectar. Panelists have a preference for baobab nectar with one thermal treatment. Pasteurized baobab nectar has a low microbiological load whatever the pasteurization scale provided that the temperature is high enough to inhibit yeasts and moulds. A storage experiment integrating processors practices and modified techniques are necessary for technological optimization that promotes nutrients retention and safety.

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Selected references

1. Assogbadjo A.E., Chadare F.J., Glele Kakai R., Fandohan B. et Baidu-Forson J.J. (2012). Variation in biochemical composition of baobab (*Adansonia digitata*) pulp, leaves and seeds in relation to soil types and tree provenances. *Agriculture, Ecosystems and Environment* 157: 94– 99
2. Cissé M., Sakho M., Dornier M., Diop C. M., Reynes M. et Sock O. (2009), Caractérisation du fruit du baobab et étude de sa transformation en nectar. *Fruit*s, 64 19-34
3. Chadare F.J., Hounhouigan J.D., Linnemann A.R., Nout M.J.R. et van Boekel M.A.J.S. (2008). Indigenous knowledge and processing of *Adansonia digitata* L. food products in Benin. *Ecology of food and nutrition*, 47(4): 338-362
4. Chadare F.J., Linnemann A.R., Hounhouigan J.D., Nout M.J.R. et Van Boekel M.A.J.S. (2009). Baobab Food Products: A Review on their Composition and Nutritional Value. *Critical reviews in Food Science and Nutrition*., 49:254-274
5. Giraud J. et Galzy P. (1980) *L'analyse microbiologique dans les industries alimentaires*. Edit. L'Usine Nouvelle, Paris – France, 236p.
6. ISO 15214 : 2008 (F) ; Méthode horizontale pour le dénombrement des bactéries lactiques : Technique par comptage des colonies à 30°C
7. ISO 21527-2 : 2008 ; Méthode horizontale pour le dénombrement des levures et moisissures. Partie 2 : Technique par comptage des colonies dans des produits à l'activité d'eau inférieure ou égale à 0,95
8. Parkouda C., Diawara B., Ganou L. et Lamien N. (2007). Potentialités nutritionnelles des produits de 16 espèces fruitières locales au Burkina Faso. *Science et technique* p40
9. Watts B.M., Ylimaki G.L., Jeffery L.E. et Elias L.G. (1991). *Méthodes de base de l'évaluation sensorielle des aliments*. CRDI. Ottawa. 145p
10. Kenya Standard, 2016 Fruit juices and nectars - Specification. 24p

Abstract submitted by the MSc Student 3

Mariette Agbohessou

Vegetative propagation of *Adansonia digitata* L.: a review

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Abstract

African baobab (*Adansonia digitata* L.) is a large tree which socio-economic importance is well established. Almost all parts of this tree are used for various purposes. The leaves are very rich in vitamin C, pro-vitamin A, iron and contain important mucilages. The young leaves of the species can be cooked and eaten as a vegetable but most often they are dried and powdered. The pulp of the fruit traditionally enters in the preparation of several beverages due to its richness in vitamin C, calcium, magnesium and other important minerals. Nowadays, the pulp is sold in many European and American countries, making baobab a highly important commodity. Yet, most current utilisations are based on wild populations and recent investigations predict sharp decline of the natural populations making urgent to engage the species domestication. Vegetative propagations are methods of multiplication that offer several advantages especially with regards to consumers' preferences and precociousness. This work aims to review current knowledge on the different vegetative propagation methods of baobab and to discuss future perspectives for mainstreaming baobab-based agroforestry systems into diversification and poverty alleviation programs. Existing literature on different methods of baobab propagation were assessed. We found that cutting, grafting and *in vitro* multiplication using two-node segments are the vegetative propagation methods already tested on baobab. The results showed that the success of grafting fluctuates from 10-89% when considering the modality of this method. The Murashige & Skoog environment supplemented or not with phytohormones is the best condition for the *in vitro* reactivity of *A. digitata* explants, regardless of their types. The success rate averages 30 percent when Indole-3-butyric acid (AIB) hormone is used considering cuttings. Other approaches such as air layering technics are still being tested in order to identify the best method to recommend for rapid and efficient propagation of the species.
Keywords: baobab, domestication, cuttings, grafting, layering, multiplication.

Résumé

Le baobab africain (*Adansonia digitata* L.) est un grand arbre dont l'importance n'est plus à démontrer. En effet, presque toutes les parties de cet arbre sont utilisées à diverses fins. Les feuilles sont très riches en vitamines C, en pro-vitamine A, en fer et contiennent des mucilages (10 % ms). Les plus jeunes peuvent être consommées comme légume mais le plus fréquemment elles sont séchées puis réduites en poudre. La pulpe du fruit entre traditionnellement dans la préparation de plusieurs maladies car, riche en vitamine C, en calcium, en magnésium et en sels minéraux. De plus, les feuilles et l'écorce du baobab sont utilisées dans le traitement de plusieurs maladies comme le paludisme, l'anémie, la diarrhée et les infections microbiennes. Les graines sont une vraie source de protéines et de lipides. A ce titre, l'espèce devient une source de revenus et de sécurité alimentaire pour les communautés locales. Ainsi, on assiste à une pression sur l'espèce qui devient menacée. La domestication de l'espèce en passant par la multiplication végétative est une solution pour pallier au problème de la pression exercée sur l'espèce en

milieu naturel en ce sens qu'elle permet de reproduire les traits caractéristiques désirés et ceci en un temps plus court que la reproduction par graines. Ce travail a pour objectif de faire la synthèse des connaissances actuelles sur les différentes méthodes de multiplication végétative du baobab et de donner des perspectives futures pour une meilleure propagation. La littérature existante sur les différentes méthodes de reproduction du baobab a été consultée. Il en ressort que le bouturage, le greffage et la multiplication *in vitro* en utilisant des segments de nœuds sont les méthodes de multiplication végétative déjà testées sur le baobab à ce jour. Les méthodes citées ci-dessus n'étant pas les seules méthodes de propagation végétative, il faudra penser à faire le marcottage terrestre et aérien par exemple, faire une étude comparative de toutes les méthodes possibles afin de mettre à disposition la meilleure méthode utilisable par les populations afin de multiplier l'espèce.

Mots-clés: Baobab, bouturage, greffage, marcottage, multiplication, domestication.

Introduction

Adansonia digitata L., the African baobab is characteristic of the Sahelian zones and belongs to the Malvaceae family. It is the only species among the eight of the genus Adansonia occurring in West Africa (Wickens and Lowé, 2008). African baobab is a large tree with 18 to 25 m of height and 5 m to 10 m of diameter. The tree gives hanging flowers and produces capsules that contain numerous seeds surrounded by a floury pulp. Baobab flowers are used in the preparation of 'potash' used in human nutrition. Nectar is also sucked by children as a dessert or snack. There are many income-generating activities around the species in sub-Saharan Africa (Gebauer *et al.* 2016). The leaves are used as vegetables; they are rich in vitamin C, pro-vitamin A, mineral salts, and iron (Kamatou *et al.* 2011). The leaves and bark are used in the treatment of several diseases such as malaria, tuberculosis, microbial infections, diarrhoea, anaemia, etc. (Watt and Breyer-Brandwijk, 1962; Adesanya *et al.* 1988; Abbiw, 1990; Van Wyk and Gericke, 2000; Brendler *et al.* 2003; Tapsoba and Deschamps, 2006; Wickens and Lowe, 2008, De Caluwe *et al.* 2009; Nguta *et al.* 2010). Fruit pulp is used in folk medicine as a febrifuge (Ramadan *et al.* 1994; Bosch *et al.* 2004; Sidibe and Williams, 2002). Recently, baobab has been referred to as a "superfruit" based on its nutritional profile (e.g. vitamin, fatty acid, and mineral). For instance, the consumption of 40 g of baobab pulp provides 100% of the recommended daily intake of vitamin C in pregnant women (19–30 years) (Chadare *et al*. 2009). Its fruit pulp has very high vitamin C content (up to 500 mg/100g dw, ~ ten times more than that of orange, and three times that of chocolate milk), hence a high anti-oxidant property . Leaves contains important amounts of minerals namely Iron and Calcium and vitamins namely pro Vitamin A (Chadare *et al.* 2009, Chadare *et al*. 2014). These micronutrients are also bioavailable for human body (Chadare *et al*. 2009). Due to this exceptional nutritional value, baobab has been acknowledged as a novel food by the European Union in 2008 (regulation EC N°258/97 of the European Parliament) and also accepted as food ingredients in the US (Addy 2009). The pulp is also nowadays sold in many European and American countries, making baobab a highly important commodity. This importance and exploitation have put wild populations of baobab into severe threats and domestication of the species has become urgent. The cultivation of baobab will not only help to reduce the pressure on the baobab natural individuals but also to cover the growing demands of the population for baobab products. When reproduced by seed, the first flowers of the baobab appear 8-23 years later (Diop *et al.* 2005) and the young trees may not be identical to the parental ones (Assogbadjo *et al.* 2006). Vegetative propagation is the type of propagation that uses fragment of the vegetative system to propagate the plant. The different variants most commonly used in rural areas are cuttings, layering and grafting (ICRAF, 2011). The advantages of vegetative propagation over seed-based propagation are: earlier fruiting of trees; the integral transfer of the hereditary characters of the mother tree to descendants; the multiplication of species whose seeds are not available; and the better timing of the production because it no longer depends on the fruiting seasons. However, the risk of intensification of diseases is great; the chances of creating new varieties are reduced and the techniques are more expensive and require much more expertise (ICRAF, 2011). Vegetative propagation also offers the advantages to fix desirable traits, especially with regards to consumer's preferences. For example, grafted plants have similar characteristic traits to the parental plants and can shorten period for fruit production. These grafted plants can begin to flower less than 5 years after grafting (Sidibe & Williams 2002). Grafting is a vegetative propagation method that can be a powerful tool for reproducing the desirable phenotypic traits of baobab (Simons & Leakey 2004; Akinnifesi *et al.* 2008). This study aims to review different methods of vegetative propagation of baobab tree and then discuss future prospects for the species domestication.

2. Methods

Scientific articles and technical documents were researched in Google scholar and ResearchGate on the various methods of propagation of baobab. The key words used for our research were: baobab, domestication, cuttings, grafting, layering, multiplication. The obtained articles were summarized.

3. Results

African baobab is naturally distributed in most countries of the sub-Sahara region (Wickens, 1982). Within some of these countries, its distribution is limited. This is the case, for example, of Chad, where the species is absent in the eastern part of the country, and South Africa where it is transversely distributed (Wickens, 1982). Although it is a savannah and dry zone species (FAO, 1988), baobab is found in the wetlands of Equatorial Africa (Gabon, southern Cameroon and Democratic Congo). It is also present on São Tomé, Madagascar and Comoros Islands. Baobab can withstand very high temperatures as well as very low temperatures (42 °- 20° C) (Simpson, 1995). The altitude for good baobab growth vary between 450 and 600 m, but several authors reported its presence at altitudes ranging from 1 m in Benin to 1500 m in Ethiopia (Wickens 1982, Wilson 1988, von Carlowitz 1991).

Cuttings

It is advisable to choose the cuttings of about 10 cm (Assogbadjo *et al.* 2009). This consists to : (i) fill the polyethylene bags with well compacted (sterilized or non-sterilized) substrates; (ii) choose a young baobab plant obtained from seed germination; (iii) prune at the young plant and this with a secateur the leaves of the cuttings chosen before cutting them from the mother plant; (iv) cut cuttings with a diameter of about 10 cm using sterilized pruning shears; (v) cut the base of the cutting at a right angle; (vi) preferably immerse the base of the cutting into the previously prepared hormones (1% Indole-3-butyric acid); a non-use of hormone significantly reduces the rate of recovery; (vii) place the cuttings vertically in a hole approximately 2 cm deep so that the bud is just above the surface of the substrate; (viii) ensure that the substrate is well packed around the cuttings; and (ix) water the cuttings to prevent them from drying out.

Photo1 : Resumption of young baobab cuttings (Assogbadjo *et al.* 2009)

Baobab tree can be propagated by cutting method. The success rate averages 30 percent when Indole-3-butyric acid (AIB) hormone is used. This success rate is about 2 percent without hormone (Assogbadjo *et al.* 2009). The advantage of this method is to multiply clones in a relatively short period (Assogbadjo *et al.* 2009). The flow diagram for the processing of baobab cutting is shown in figure 1.

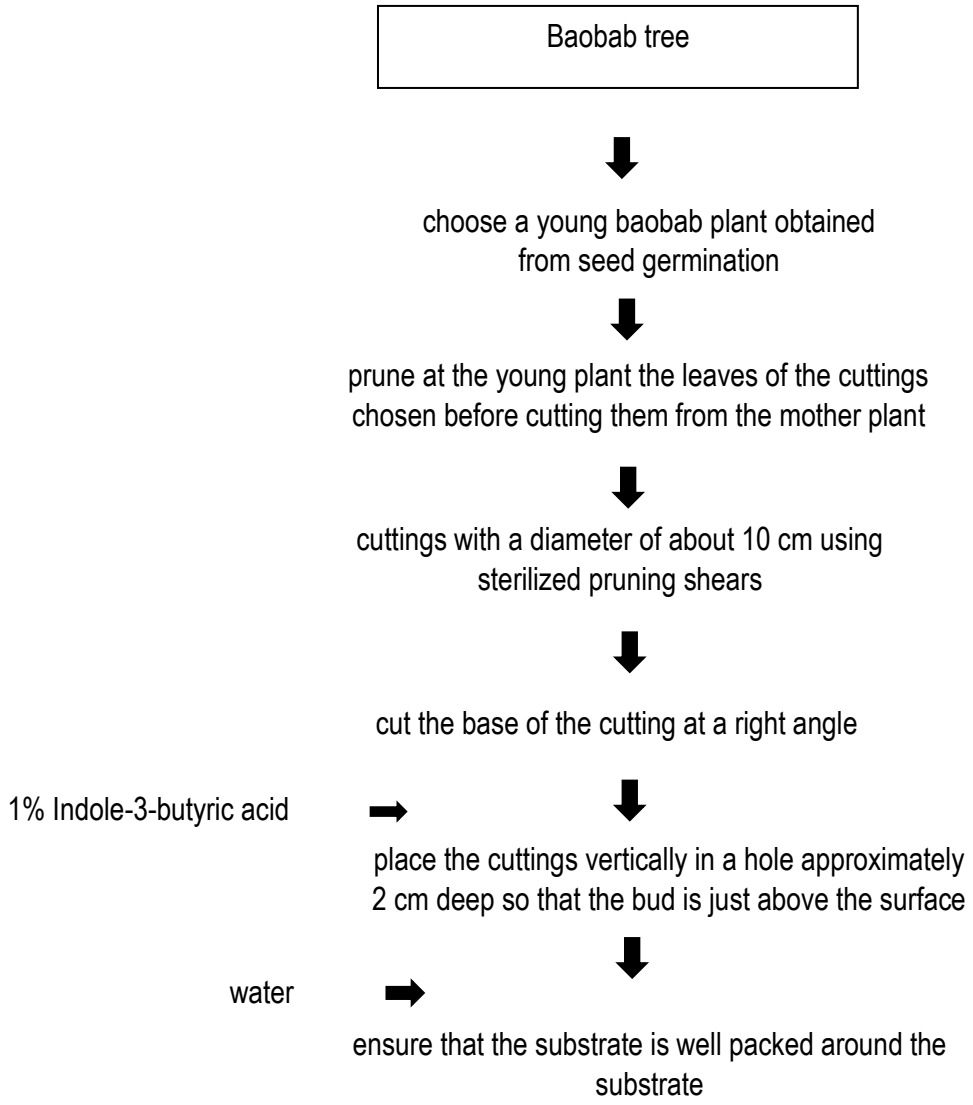

Figure 1: Processing diagram of baobab cuttings

Grafting

To graft baobab tree, we need a graft about 10 cm of long and 1 cm in diameter and a rootstock from a young baobab tree. The graft must be mature and must be between 6 and 9 months. The different stages of the side veneer technic used to graft baobab consist of: (i) identify at the level of a young baobab plant the grafts to be used; (ii) remove, one week before the grafting operation, the grafts from their leaves before separating them from the mother plant; (iii) directly collect the grafts on the chosen plant just before the grafting; (iv) select a healthy, vigorous baobab seedling that is the rootstock; (v) prune and topping the rootstock; (vi) toast the graft just above an eye; (vii) make an oblique cut on the graft of the same notch as that of the rootstock so that they interpenetrate;(viii) remove a slice of bark and wood about 4 cm long on the stem of the rootstock until it reaches the sapwood; (ix) tightly ligate with polyethylene tape; (x) protect both plants with a waxed cloth and water them well until the graft has taken and remove the

ribbon once recovery is complete period (Assogbadjo *et al.* 2009). Grafting of baobab is shown in photo 2.

Photo 2: Grafting of baobab (Agbohessou,2018)

The choice of grafts and rootstocks should be based on the preferences of the populations. Grafting has the characteristics of adding the quantitative traits of the strains used, shortening the reproduction period and being realized at any time of the year. Side veneer grafting method and top cleft grafting method (Anjarwalla *et al.* 2016) were tested on baobab. Grafts are collected on tree (on the basis of their fruiting performance for example). The grafts had about 20cm. These grafts were then grafted onto grafting doors from seedlings and different ages: 1 year and 2 years. The best results were obtained on baobab grafted onto 2-year-old rootstocks using the side veneer grafting method (55%) and top cleft grafting method (71%). Herbert *et al. (*2018) reported for top cleft (66.6%) and for side veneer (63.3%). Lowest survival rates were obtained on rootstocks of 1-year-old rootstocks using side veneer grafting method and the top cleft grafting method (Anjarwalla *et al.* 2016). A comparison of the two methods showed that with the top cleft technique, the average shoots length is higher compared to the average shoot length with the side veneer grafting method (*Anjarwalla et al.* 2016). The grafting success is strongly influenced by the period of the year in which it is achieved Herbert *et al. (*2018). Growth hormones should be concentrated in the buds to promote differentiation of vascular elements in the graft tissues (Hartmann *et al.* 2002). In order to assess the best time of year for baobab grafting, grafts should be harvested and grafted at different times of the year when they are at different physiological levels and at different stages of growth, while considering the variation in conditions (Anjarwalla *et al.* 2016). In addition, the studies of Herbert *et al. (*2018) revealed significant difference between grafting methods in two different months: October and december. Shoot growth was 3.30 ± 0.708 cm for side veneer and 2.70 ± 0.713 cm for top cleft. Those results indicate that baobab is easily amenable to grafting when the grafting is done at the right time (Herbert *et al.* 2018).

In Vitro propagation

N'Doyé *et al. (*2012) have studied the optimal conditions for in vitro propagation of the baobab tree that would allow a mass production of plants for their subsequent introduction into the planting areas. The reactivity rate is 100% for apex, cotyledonary and axillary nodes cultured in various media. The number of newly formed shoots depends on the type of explant but also the nature and concentration of the hormone. It is the same for the average shoot length of and the mean number of newly formed nodes.

The results of this study showed that Murashige & Skoog (MS) environment supplemented or not with phytohormones is efficient for the in vitro reactivity of *Adansonia digitata*'s explants, regardless of their types for micropopagation. *A. digitata* explants react spontaneously in MS culture media containing or not growth regulators (N'Doyé *et al.* 2012).

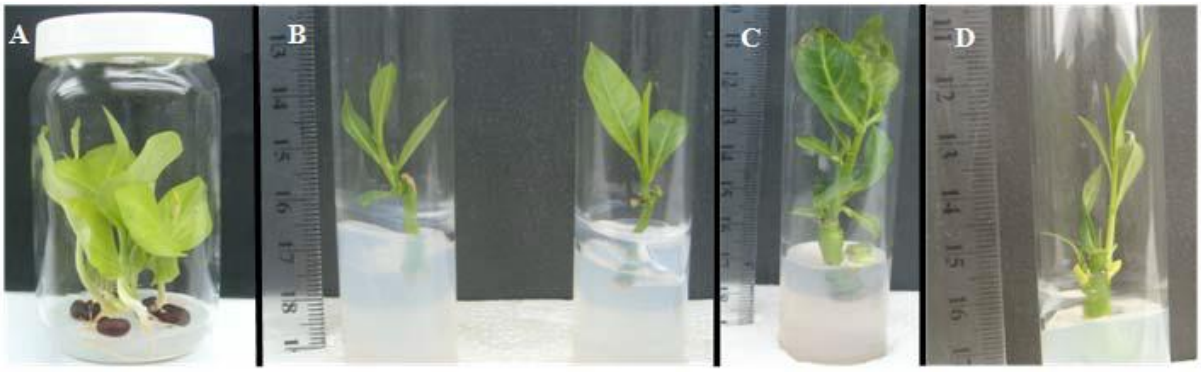

Photo 3: A. Sterile seedlings of *A. digitata*; B. Apex (APX); C. Axillary nodes (AN); D. Cotyledonary node (CN) neoformed (N'Doyé *et al.* 2012).

The number of newly formed shoots depends on the type of explant but also the nature and concentration of the hormone. The same goes for the average shoot length and the average number of neoformed nodes. Growth regulators also have favourable effect on the formation of baobab roots in the *in vitro* culture. Thirty days after planting, the best medium for the growth of *A. digitata* explants is the medium MS + 6-benzyl aminopurine (BAP) 0.5 mg L-1 (N'Doyé *et al.* 2012). Comparing the growth rate of explants grown on MS media containing different cytokinins like BAP and Kinetin has allowed to determine that the BAP is more effective than kinetin for the formation of new shoots whatever the type of explant tested (N'Doyé *et al.* 2012). So, in the absence of any polyphenolic interactions, which could interact on morphogenetic capacities of baobab explants, due to the power of activated charcoal adsorbent on baobab explants, the BAP is more organogenic at the same concentration than Kinetin.

In vitro propagation of *Adansonia digitata* using two-node segments

Using two-nodes segment is an *in vitro* propagation method tested by Rolli *et al.* (2014) due to the low germinability of baobab seeds. For Rolli *et al.* (2014), micropropagation was tested as a method for clonal propagation of explants from *in vivo*-grown seedlings. *In vitro* shoot multiplication was achieved through enhanced axillary bud proliferation of sterilized two-node segments. The shoots propagation *in vitro* was achieved. The best results were obtained with MS environment supplemented with 10 mM of zeatin riboside (ZR) alone or with combinations of 1.0 or 10.0 mM ZR and 10.0 mM IBA on shoots development. In the presence of these proliferative conditions, the highest percentage of regenerating explants was obtained, callus formation was limited to the basal part of the two-nodes segment and completely absent in the regenerated shoots (Rolli *et al.* 2014). In addition, the shoots obtained developed well, both in terms of mean number of nodes and shoot length. The seeds subjected to chemical scarification gave a very high germination rate. All seeds were developed and differentiated into seedlings. In addition, using IBA at 10µM is the best option for having high rate of rooting (Rolli *et al.* 2014). The best rate of survival were 77.77 %, 72.72 % and 57.14 % respectively for plants formed from the apex, plants stemming from the axillary nodes and for those formed from cotyledons. Using two-node segments from in vivo-germinated seedlings represents a good starting material for *A. digitata* in vitro culture because plant tissues in vegetative phase were resilient to sterilization with sodium hypochlorite.

5. Conclusion

From the current knowledge, cutting and grafting could be the best regeneration option known to propagate baobab by vegetative way. We also have *in vitro* propagation and *in vitro* propagation using two-node segments. Additional work is necessary to increase the success of vegetative propagation methods. For example, air and terrestrial layering can be tested, and a comparative study of all the possible methods in order to make available the best method usable by the populations in order to multiply the species and thus reduce pressures in the natural environment.

Acknowledgements

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Selected references

1. **Akinnifesi F.K., Leakey R.R.B., Ajayi O.C., Sileshi G., Tchoundjeu Z., Matakala P., Kwesiga F.R. 2008.** Indigenous fruit trees in the tropics: domestication, utilization and commercialization. Wallingford: CAB International, in association with the World Agroforestry Centre Nairobi, Kenya.
2. **Anjarwalla P., Ofori D., Owino A., Matuku D., Adika W., Njogu K., Kehlenbeck K. 2016**. Testing different grafting methods for vegetative propagation of baobab (*Adansonia digitata* L.) in Kenya to assist its domestication and promote cultivation, Forests, Trees and Livelihoods, DOI: 10.1080/14728028.2016.1202791
3. **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). Annals Botanic. 97:819–830.
4. **Assogbadjo A.E., Sinsin B., De Caluwe E., Van Damme P. 2009.** Développement et domestication du baobab au Bénin. LEA-FSAUAC / DADOBAT, Cotonou, Bénin. 73p. ISBN: 978-99919-63-69-3.
5. **Chadare, F. J., Linnemann A. R., Hounhouigan J. D., Nout M. J. R., and van Boekel M. A. J. S. 2009.** Baobab food products: a review on their composition and nutritional value. Critical Reviews in Food Science and Nutrition 49:254-274.
6. **De Caluwe E., De Smedt S., 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 African Journal of Ecology., 47: 433-440.
7. **Diop A.G., Sakho M., Dornier M., Cissé M., Reynes M. 2005.** Le baobab africain (*Adansonia digitata* L.): principales caractéristiques et utilisations. Fruits, 61(1): 55-69
8. **Herbert J., Chimuleke R. Y., Munthali, Mhango J. 2018.** Amenability of African baobab (*Adansonia digitata* L.) to vegetative propagation techniques, Journal of Sustainable Forestry, 37:6, 632-644, DOI: 10.1080/10549811.2018.1449123
9. **N'doye A. L., Sambe M.A.N., Sy M.O. 2012.** Propagation Of African Baobab (*Adansonia digitata* L., Bombacoideae, Malvaceae) Germplasm Through In Vitro Cloning. Adv Environ Biol 6: 2749-2757.
10. **Rolli E., Brunoni F., Bruni R. 2014**. An optimized method for in vitro propagation of African baobab (*Adansonia digitata* L.) using two-node segments, Plant Biosystems - An International Journal Dealing with all Aspects of Plant Biology: Official Journal of the Societa Botanica Italiana, DOI: 10.1080/11263504.2014.991362.

Communication submitted by the TVETs

Contribution de l'enseignement agricole au développement local : cas des Lycées Agricoles Médji de Sékou et de Natitingou (Bénin, Afrique de l'Ouest)

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Résumé

Les Lycées Techniques Agricoles (LTA) A à travers leurs missions et objectifs jouent un rôle primordial dans le développement du Bénin. En effet, ces centres de formation ont mis à la disposition de l'Etat des compétences variées qui ont accompagné l'encadrement des producteurs depuis les périodes coloniales jusqu'à nos jours. Il s'agit d'agents techniques dévoués à l'exécution des différentes taches indispensables pour l'encadrement des producteurs. Ils fournissent aussi des compétences spécifiques aux entreprises agricoles, aux organisations non-gouvernementales intervenant dans l'appui-conseil aux producteurs. A travers les collaborations avec des partenaires multiples, ces institutions contribuent au développement local du pays.

Mots-clés : Auto-emploi, entreprise agricole, Formation agricole,

Summary

Technical and vocational education and training (TVET) institutions through their missions and objectives play a key role in the development of Benin. Indeed, these institutions provided various skills for the technical support to farmers from colonial period to date. Their graduates are technical agents dedicated to the execution of essential tasks to help producers for the improvement of agricultural productivity. They also provide specific skills to agricultural enterprises, non-governmental organizations involved in advising local farmers. Through collaborations with multiple partners, these institutions contribute to the local development of the country.

Keywords: Agricultural business, Agricultural training, Self-employment

1. Introduction

La création des institutions de formation ou de recherche dans le domaine de l'agriculture au Bénin est marquée par trois périodes spécifiques suivant les aspirations des gouvernants. Dès les années 1900, la France, colonisateur du Bénin, avait besoin de matières premières pour alimenter ses industries. Le développement de ces plantes et cultures au niveau des territoires colonisés a besoin de ressources humaines qualifiées formées localement. D'où l'idée de mettre en place à proximité des centres de

recherche, un dispositif de formation du personnel technique d'appoint afin d'appuyer les « jardins d'acclimatation et jardins d'essais » qui, avec le temps, vont devenir des centres de recherche agronomique et zootechnique. Ce dispositif de recherche est mis en relation avec un centre de recherche à Montpellier en France pour l'introduction dans les territoires explorés, de plantes utiles à la métropole. C'est dans ce contexte qu'est né en 1914, le premier Centre d'Apprentissage Agricole (CAA) de Porto-Novo qui va devenir en 1954 le Centre Technique Agricole (CTA). Ce centre a rang d'école régionale parce que devant servir le Dahomey, le Togo et la Côte d'Ivoire. Le CTA avait pour mission de former des contremaîtres de cultures, des agents pour les coopératives et les sociétés de prévoyance et des aides-conducteurs des travaux agricoles et des aides-assistants de laboratoire. Sur instruction du gouverneur fédéral le CTA de Porto-Novo va être transféré en Côte-d'Ivoire. En lieu et place est créé l'Ecole de Pratique Agricole (EPA) de Porto-Novo qui a pour mission de former des techniciens agricoles pour assurer la vulgarisation agricole auprès des agriculteurs.

A l'accession du pays à l'indépendance, l'enseignement agricole et la recherche agronomique dépendaient de la même direction à savoir la Direction de Enseignement et de la Recherche Agricole. Cette direction a restructuré l'enseignement agricole en 4 niveaux à savoir : (i) le niveau « Lycée Agricole » qui forme les agents de maîtrise, d'encadrement pour les organismes professionnels agricoles et para-agricoles, les collectivités rurales, les services publics, les sociétés ; (ii) le niveau « Centre de Formation Rurale » (CFR) qui forme des agents de base d'encadrement pour les organismes professionnels agricoles et para-agricoles, les collectivités rurales, les services publics, les sociétés ; (iii) le niveau « Centre de Formation Permanente » (CFP) qui assure le recyclage et le perfectionnement de tous les agents du développement et de la coopération, ainsi que des agents de tout organisme public et privé qui en font la demande ; et (iv) le niveau « Centre de Formation Professionnelle Agricole » (CFPA) qui assure la formation des jeunes agriculteurs.

A l'avènement de la révolution entre 1975 et 1989, les CFR au nombre de 3 ont changé de dénomination pour devenir Complexes Polytechniques Agricoles niveau 1 (CPA 1) tout en conservant la mission de départ. Le seul lycée agricole, le LAMS subit également la mutation pour devenir Complexe Polytechnique Agricole niveau2 (CPA2). A partir de 1990, la période du renouveau démocratique les CPA1 sont devenus « Collège d'Enseignement Technique Agricole (CETA) » et le CPA 2, redevenu le LAMS jusqu'à la création d'autres lycées agricoles avec diverses dénomination (Lycée Technique Agricole (LTA) ou encore Lycée Technique Agropastoral (LTA). Pour ces deux catégories, on dénombre en 2018 dix établissements.

La présente communication analyse la contribution de ces institutions de formation agricole au développement local au Bénin. Elle s'intéresse spécifiquement au Lycée Agricole Médji de Sékou et au Lycée Technique Agricole de Natitingou.

Le Lycée Agricole Médji de Sékou (LAMS) est un lycée public de formation agricole mixte et à régime internat et externat. Il a été créé en 1963 sur une superficie de près de 200 hectares. Il offre des cours initiaux, des cours à distance ainsi que des formations modulaires et qualifiante dans les principales filières de l'enseignement technique et professionnel agricole au Bénin.

Le Lycée Technique Agricole (LTA) de Natitingou, est l'un des dix Lycées Techniques Agricoles existant au Bénin en 2018. Il a été créé en mars 1998 sous l'appellation du Collège d'Enseignement Technique Agricole (CETA) pour offrir des formations diplômantes dans le secteur agricole.

2. Matériel et méthodes

Les informations synthétisées dans cette communication sont issues de la revue documentaire basée sur l'exploitation des rapports annuels des lycées techniques agricoles. Les documents d'orientation sur l'éducation nationale au Bénin ont été également consultés. Les forces, faiblesses, opportunités et menaces ont été répertoriées à travers une analyse SWOT.

3. Résultats et discussion

3.1. Mission et objectifs des lycées techniques agricoles

Les lycées techniques agricoles ont pour mission de former (savoir et savoir-faire) et d'éduquer (savoir-être) dans le domaine agricole. De ce fait, leurs principaux objectifs sont entre autres de (i) faire acquérir aux jeunes élèves les connaissances fondamentales et technique dans le secteur agricole (formation initiale) ; (ii) assurer la formation professionnelle continue aux actifs agricoles dans une vision d'auto installation ; (iii) produire et vulgariser de nouvelles technologies en matière agricole.

Cette mission et ces objectifs permettent aux LTA d'appuyer de manière durable le développement du secteur agricole au Bénin à travers :

- La mise à disposition des entreprises agricoles de la main d'œuvre qualifiée
- L'amélioration de la compétitivité et de la performance des entreprises agricoles
- La qualification professionnelle des jeunes en vue de leur insertion dans la vie active

3.2. Statistiques sur les apprenants au sein des deux LTA durant les dix dernières années

Sur les dix dernières années (2008 à 2018), des centaines d'apprenants ont été formés par les deux lycées techniques agricoles. Durant cette période, l'effectif total des élèves oscille entre 1600 et 1200 au Lycée Agricole Médji de Sékou (Figure 1a), et entre 200 et 850 au Lycée Technique Agricole de Natitingou (Figure 1b). L'évolution de cet effectif montre que la situation est plus ou moins stable avec une légère tendance à la baisse au niveau du LAMS. Au niveau du LTA de Natitingou, c'est plutôt une tendance à la croissance qui se note. Cette situation au niveau du LAMS peut s'expliquer par l'ancienneté de l'établissement et aussi par le fait que plusieurs LTA ont été créés récemment dans le pays (c'est le cas du LTA de Natitingou).

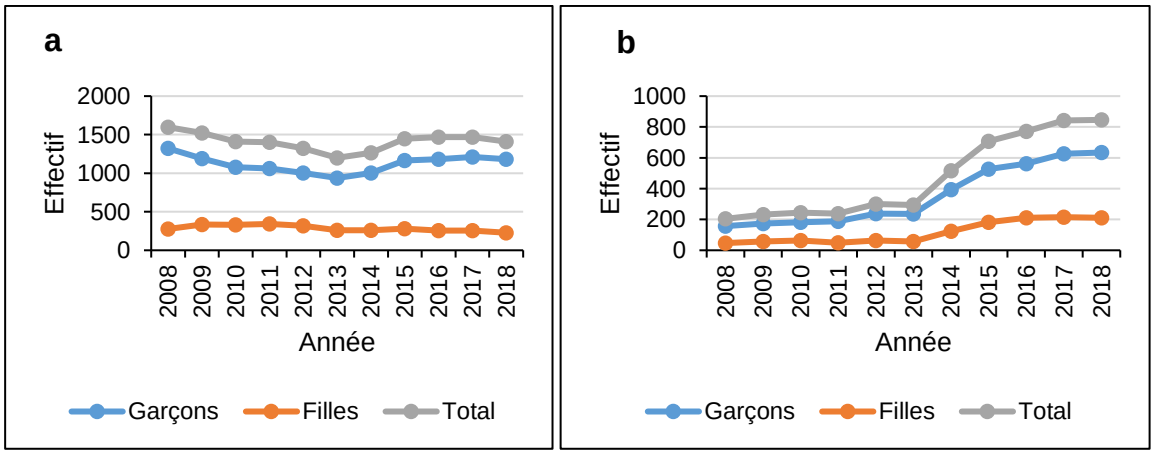

Figure 1 : Evolution de l'effectif des apprenants au sein des deux Lycées Techniques Agricoles (a. Lycée Agricole Médji de Sékou ; b. Lycée Technique Agricole de Natitingou).

3.3. Formations offertes

Les LTA offrent des formations techniques aux jeunes entrepreneurs agricoles polyvalents pour l'obtention du Brevet d'Etudes Agricoles Tropicales (BEAT) et/ou du Diplôme d'Etudes Agricoles Tropicales (DEAT). Le BEAT s'obtient à l'issue du cursus du Niveau I qui dure 4 ans. Parmi les deux LTA considérés dans cette communication, seul le LTA de Natitingou dispose de ce niveau de formation, et ce niveau ne couvre que deux filières (production végétale et production animale). Le DEAT quant à lui, s'obtient à la fin des études du niveau II. Il dure aussi 4 ans et se fait dans plusieurs spécialités de l'agriculture (Tableau 1).

Tableau 1 : Spécialités de formation et compétences spécifiques offertes dans les LTA

Options	Compétences spécifiques
Production Végétale	Maraichage (cultures des légumes) ; Grandes cultures vivrières ; Cultures industrielles ; Horticultures fruitières ; Horticulture ornementale (Floriculture)
Production Animale	Elevage des volailles (aviculture) ; Porciculture (élevage des porcs) ; Elevage des ovins et caprins ; Elevage des bovins ; Elevage des lapins (cuniculture) ; Fabrication de la provende
Foresterie	Production des jeunes plants forestiers (Pépiniériste) ; Mise en place et suivi des plantations forestières ; Héliciculture (élevage des escargots) ; Production du miel (apiculture) ; Production de champignons comestibles
Nutrition et Technologie Alimentaire	Production de jus et de sirop de fruits (orange, mangue, ananas, soja, baobab, ...) ; Production de purée (tomate, piment, …) ; Production de yaourt ; Production de gari et du tapioca ; Production des huiles ; Fumage de viande et de poisson ; Production d'alcool ; …
Aménagement et Équipement Rural	Construction rurale (animaleries, pistes rurales, étangs et bassins piscicoles, ponceaux, digues, etc.) ; Machinisme agricole (tractoriste, …) ; Installation des étangs et bassins piscicoles ; Construction des foyers améliorés ; Hydraulique agricole (installation des systèmes d'irrigation) ; …
Pêche et Aquaculture	Production des alevins ; Elevage de poissons ; Fabrication de la provende de poisson

Outre la formation initiale diplômante, les LTA, notamment le LAMS, disposent de Cellule de Formation Continue Agricole (CFC) qui organise des sessions de formation continue ou modulaire. Cette formation continue qualifiante est organisée au profit des acteurs qui travaillent déjà (fonctionnaires d'Etat ou même du privé) et aussi des exploitants agricoles désireux d'avoir une qualification professionnelle dans un domaine précis de l'agriculture ou désireux d'avoir le DEAT. La durée de formation qualifiante varie suivant le ou les modules de formation sollicités. Quant à la formation donnant droit au DEAT, elle se déroule sur cinq (05) années scolaires avec deux (02) regroupements par an.

3.4. Débouchés potentiels des diplômés des LTA

Quel que soit la spécialité choisie, à la fin de leur formation, les diplômés des LTA sont capables de :

- ✓ S'auto – employer en créant et/ou en gérant des entreprises (fermes) agricoles et agro-alimentaires.

- ✓ Jouer le rôle de conseiller agricole auprès des producteurs et productrices à la base dans les communautés rurales (animateurs d'ONGs ou d'associations de producteurs, programmes et/ou projets de développement agricole et de sécurité alimentaire, …).
- ✓ Servir comme Agent technicien spécialisé dans de diverses structures agricoles et de gestion de l'environnement.

En clair, ce type de formation permet aux diplômés des LTA de vite s'insérer dans la vie professionnelle contrairement aux diplômés du système d'enseignement général. Toutefois, les LTA ont connu des ajustements dans leur dispositif de formation compte tenu des différentes crise économique et financière traversé par le pays. En effet, en 1986, le gouvernement a gelé le recrutement systématique dans la fonction publique pour raison de crise économique et financière. Ceci a obligé les LTA a révisé leur curricula de formation en 1996 afin d'orienter prioritairement les diplômés vers l'auto-emploi. Ceci a eu pour effet la pluralité des débouchés aux diplômés (secteur public, secteur privé, organisation de la société civile, …). Les diplômés des LTA ont alors plusieurs destinations :

- Poursuite systématique des études supérieures (40 à 45 %) : les principales filières d'accueil de ces diplômés au niveau des universités sont la sociologie, la géographie, les sciences juridiques, et l'agronomie.
- Emplois salariés dans le domaine agricole (25 à 30 %) : Ils s'insèrent aussi bien au niveau de l'administration publique (54 %) que dans le secteur privé (environ 46%).
- Autres professions (2 à 6 %) : il s'agit des professions dans des secteurs autre que celui de l'agriculture (police, gendarmerie, magistrature, enseignement, etc.).
- Auto-emploi (8 à 12 %) : Dans cette catégorie, plus 50 % des concernés s'investit dans l'agro-alimentaire, la vente des intrants vétérinaires, et dans l'élevage péri-urbain.

3.5. Matrice Forces-Faiblesses-Opportunités-Menaces des LTA

Comme toutes structures opérationnelles, les LTA présentent des forces et des faiblesses. De la même manière, des opportunités et des menaces se présentent à eux (tableau 2). Au nombre des forces, il y a la disposition de curricula de de formation bien élaborés et surtout l'engouement accru des jeunes à ce type de formation. Toutes fois, des faiblesses comme le manque de matériels pour les travaux pratiques, et le manque d'enseignants permanents entravent la bonne mise en œuvre de la mission de ces LTA. La disponibilité de plusieurs voies d'insertion des diplômés constitue une excellente opportunité pour les LTA.

Tableau 2 : Forces, faiblesses, opportunités et menaces des LTA

Forces	Faiblesses	Opportunités	Menaces
Curricula de formation bien élaborés	Insuffisance de certains matériels pour les travaux pratiques de la formation	Avenir certain pour les apprenants	Suppression éventuelle du niveau I
Formation de qualité	Manque d'enseignants permanents	Plusieurs voies d'insertion des apprenants dans la vie active (Etat, ONGs, Entreprises individuelles, …)	
Source pourvoyeurs de ressource humaine de qualité	Utilisation massive des enseignants-		

pour le développement de l'agriculture au Bénin	vacataires pour la formation		
Engouement accru des apprenants à ce type de formation			

3.6. Dispositif d'accompagnement et d'installation des formés de l'ETFPA

Plusieurs mécanismes sont mis en place pour suivre et accompagner les diplômés des LTA. Au nombre de ceux-ci, il y a le projet d'Insertion Durable des Diplômés du secteur Agropastoral (IDDA), l'incubateur Nutrition et Technologie Alimentaire du Lycée Agricole Mèdji de Sékou (NTA LAMS).

- Projet d'Insertion Durable des Diplômés du secteur Agropastoral (IDDA)

Le projet est mis en œuvre par l'ONG APRETECTRA (Association des Personnes Rénovatrices des Technologies Traditionnelles) et vise l'insertion durable, sur le marché du travail, de 1200 jeunes finissants dont 25% de femme, sortis de 3 Lycées Techniques Agricoles (LTA).

Le projet dans son exécution assure : (i) le renforcement des capacités organisationnelles, pédagogiques et techniques des Lycées Techniques Agricoles ainsi que celles des directions techniques des ministères impliquées dans le suivi des établissements ; (ii) le renforcement des compétences techniques des jeunes finissants par des stages professionnels pratiques auprès des entreprises agricoles, leurs capacités managériales et entrepreneuriales en vue de leur insertion sur le marché du travail.

Le projet appuie les jeunes à travers : (i) un aménagement sommaire de périmètres agricoles ; (ii) des dons en équipements ; (iii) Un accompagnement en vue de l'obtention de micro crédit ; (iv) Le suivi de leurs entreprises.

- Incubateur Nutrition et Technologie Alimentaire du Lycée Agricole Mèdji de Sékou (NTA LAMS)

Cet incubateur encore appelé couveuse ou pépinière d'entreprises, a pour principale mission d'accompagner les créateurs d'entreprises notamment les jeunes qui ont fini leur formation technique agricole, option nutrition et technologie alimentaire (NTA) et désireuses de s'installer à leur propre compte. Il a pour objectifs (i) la lutte contre le chômage des jeunes ; (ii) la formation des jeunes à l'auto-emploi ; (iii) la création d'emplois nouveaux ; et (iv) l'incitation à la transformation des produits agricoles.

Cette unité produit et vend différents types de produits destinés à la consommation. Les acteurs principaux sont les diplômés de l'option NTA. Elle leur facilite l'acquisition d'expériences professionnelles dans la production et la vente des produits issus de la transformation agro-alimentaire durant deux ans d'incubation. A l'issu de cette incubation, ils sont équipés afin de s'installer à leur propre compte.
Dans l'exécution des différentes tâches liées à l'incubateur, il est attribué à chaque producteur de l'équipe de production une prime forfaitaire de 20.000 par mois pour les deux premiers mois de travail puis une prime mensuelle proportionnelle aux bénéfices réalisés. La prime mensuelle est évaluée à 40% du bénéfice sur les ventes mensuelles.

Parallèlement à ces dispositions, les LTA mettent souvent en place quelques autres actions pour le suivi des diplômés. Il s'agit de :

- L'élaboration d'un répertoire des contacts téléphoniques et adresses électroniques des apprenants ;
- La mise en place d'un recueil des informations auprès des apprenants ou de leurs parents sur leur situation professionnelle,
- La réalisation d'enquête périodique auprès des structures utilisatrices des produits des lycées agricoles autres que le Ministère en charge de l'agriculture,
- Les visites de terrain organisées lors de la préparation de la mise en stage des apprenants.

3.7. Collaboration avec les universités et autres structures du secteur agriculture

En matière de coopération avec les universités et autres structures du secteur agricole, les LTA ont des relations avec :

- La coopération allemande (GIZ/PDDAA/NEPAD) à travers des contrats de partenariat avec des entreprises pour l'immersion des apprenants en fin de formation en vue de leur installation en entrepreneur agricole.
- Des ONG locales et même internationales, c'est le cas du LAMS avec l'ONG APRETECTRA (Association des Personnes Rénovatrices des Technologies Traditionnelles) à travers la mise en œuvre du Projet d'Insertion Durable des Diplômes du Secteur Agropastoral (IDDA) financé par le Canada.
- Les universités publiques et même privées, c'est le cas des deux LTA avec l'université d'Abomey Calavi, notamment la Faculté des Sciences Agronomiques (FSA) à travers le projet « Mise à échelle de la valorisation des produits alimentaires du baobab africain à travers l'amélioration de leur qualité sanitaire et chaines de valeur pour la sécurité alimentaire et nutritionnelle au Bénin (BAOCHAIN) ». Aussi, la relation entre la FSA et le LAMS est matérialisée par la mise à disposition de la FSA de parcelle sur le site du Lycée Agricole Médji de Sékou pour servir de site d'expérimentation.
- L'ambassade d'Israël à travers la mise en place d'une parcelle de démonstration au sein du lycée, la formation au Bénin et/ou en Israël des enseignants ; la mise en place d'un système de Learning by Doing des apprenants en fin de formation en Israël.
- Les entreprises agricoles du Bénin pour la mise en stage annuel des apprenants.

4. Conclusion

Les LTA ont depuis les périodes coloniales apporté leur contribution au développement du Bénin à travers la mise à disposition de compétences spécifiques dans le secteur agricole. Ces compétences ont été utiles aussi bien dans le secteur public que privé pour l'amélioration de la productivité agricole. Toutefois, de nos jours, le manque de formateurs qualifiés dans les LTA et le manque de ressources matérielles ont du mal à garantir une adéquation formation/emploi.

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Références bibliographiques

- Rapports de rentrée du LAMS des années 2008 à 2018

- Rapport atelier sur la traçabilité des apprenants au Bénin
- Document d'orientation sur l'éducation national
- Arrêté 1972/N°013/MESTFP/DC/SGM/DAF/DETFP/SA006SGG17 du 14/02/1970 portant création du Lycée Agricole Médji de Sékou