

Systematic review of studies on the nutritional value of wild food plants in Côte D'ivoire (West Africa)

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Abstract

Many plant species, which once played an important role in the survival of populations, especially in times of war, drought and invasion of crops by locusts, have disappeared or have become rare. Yet according to the Landscape Analysis, in 2009, about 13 % of rural households were in food insecurity. This situation shows the urgency of valorizing the spontaneous or wild food plants by a thorough study of their nutritional composition in order to increase the knowledge of the populations of these species and promote food consumption. The objective of this work is to provide an analysis (resulting in an overview) of the research on the nutritional values of wild food plants in Côte d'Ivoire. We conducted a systematic review of research on the nutritional values of wild food plants in Côte d'Ivoire based on the criteria by PRISMA GROUP. The study involved a detailed analysis of the work of research centers working on food plants. The results showed that out of 27 articles identified on spontaneous food species, for the period going from 2006 to 2014, only 4 studies examined their nutritional value. All work was carried out in urban areas, and 75% of the plant material was obtained in the markets. Only one study was dedicated exclusively to a specific plant species. Other studies have focused on samples of 3 to 20 species. Studies had no plant species in common. All the studies noted the high nutritional value of several spontaneous plant species but, the analytical methods used in these studies were generally low-achieving. Despite the difficult study conditions, all the studies established the good nutritional value of several spontaneous plant species. The use of these plant species could be part of the answer to the challenge of food security.

Keywords: wild food plants, spontaneous food species, nutritional value, Côte d'Ivoire

1. Introduction

Plants make up indispensable natural resources for human feeding and human care ^[1]. In West Africa, since the 90s, the destruction of the forest has been estimated at 4% per year ^[2]. The Ivorian forest would seem to have shrunk from 16 million hectares to less than 2 million in fifty years. This poses the problem of the survival of wild plants food, which constitute real sources of nutritional supplements in rural areas, as well as currency ^[3,4]. The strong growth of urban populations in Africa comes with the challenge of food security ^[3,5]. Many plant species, which once played an important role in the survival of populations, especially in times of war, drought and invasion of crops by locusts, have disappeared or have become scarce ^[6]. In this context, the wild food plants could be a solution today and play a fundamental role in the fight against hunger. According to the Landscape Analysis, in 2009, about 13% of rural households in Côte d'Ivoire were in food insecurity ^[7]. According to Rhoner and Al (2013) the prevalence of vitamin A deficiency is estimated at 24% of preschool children with a higher prevalence in rural areas (28%) than urban areas (20%). Folic acid deficiency affects almost all women, with a national prevalence in Côte d'Ivoire of 86% ^[8]. This situation shows the urgency of valorizing the spontaneous food plants by in-depth study of their nutritional composition in order to increase the knowledge of the populations of these species and promote food consumption.

In many works, the role of these neglected food sources is highlighted. This mostly concerns fruit, eaten raw or cooked,

leaves prepared in sauce, cereal, wild tubers and beverages such as palm wine ^[9]. The food and medicinal fruit species in Côte d'Ivoire have been the object of basic study in botany ^[10,11,12], ethnobotany ^[6,13], and domestication studies were initiated ^[14,15]. Apart from the biochemical and nutritional study of wild food plants in the south of V-Baoule conducted by Herzog (1992) ^[4], the nutritional value of these wild food plants has been the object of very little study in Côte d'Ivoire.

The objective of this study is to make an analysis of research on the nutritional values of wild food plants in Côte d'Ivoire.

2. Method

We conducted a systematic review based on the criteria enounced by PRISMA GROUP (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) ^[16].

2.1 Selection criteria

2.1.1 Selection of research centres: The criteria for selection of the centres were: the presence of areas of research on food plants, the existence of regularly published research reports, and collaboration with the universities of Ivory Coast. Thus, two centres have met the selection criteria. These are the National Centre for Agronomic Research (CNRA: Centre National de Recherche Agronomique) and the Swiss Centre for Scientific Research (CSRS: Centre Suisse de Recherche Scientifique).

2.1.2 Study Selection: We selected all studies on wild food plants, or spontaneous gathering Ivory Coast irrespective of

language or methodology. We excluded work on food plants eaten only by chimpanzees and on medicinal plants.

2.2 Search Strategy and Study Selection

The study involved a detailed analysis of all activity reports and all work (publications, theses, and communications) carried out on aliments from the beginning of the activity reports of each centre; i.e. since 2006 for the CSRS and since 2008 for the CNRA. Regarding the CSRS, we considered work in the field relevant to our study (Natural environments and biodiversity, Environment and health, Biodiversity and food security, Medicinal, utility and forest plants).

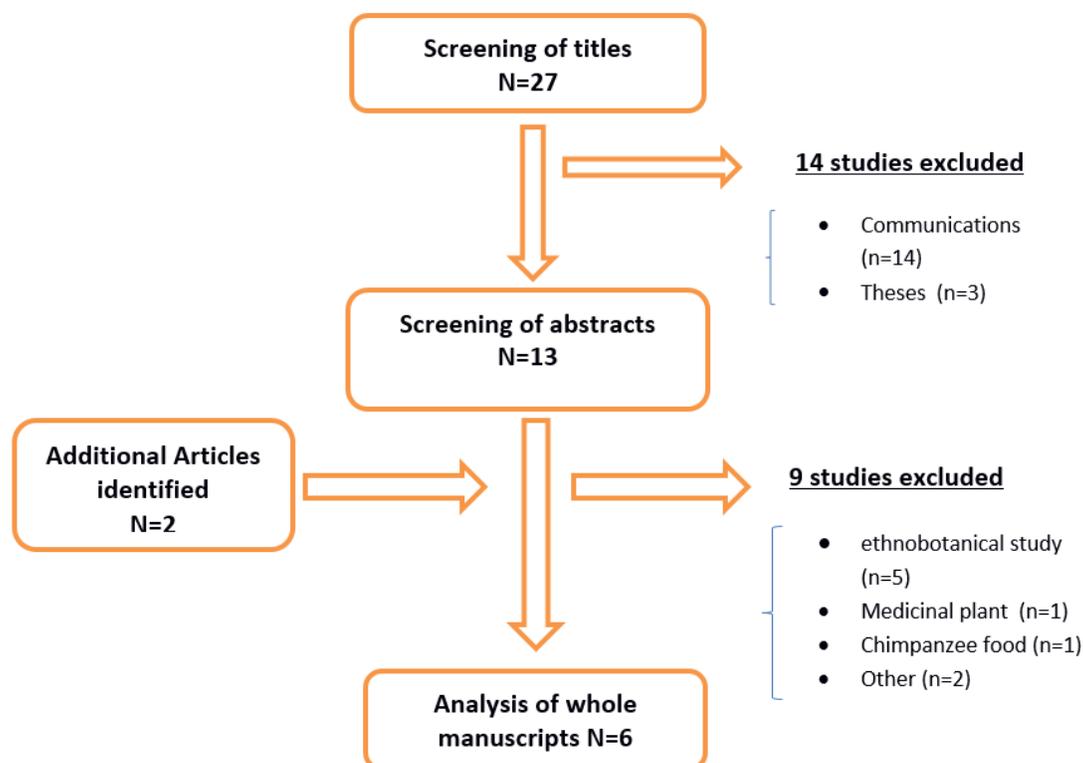
We also made use of the Pubmed database to find publications. The search was conducted with the following key words: nutritional value, Côte d'Ivoire, «neglected aliments" [17, 18], "wild food plants" [15], "collection food" [19, 20], "spontaneous food species" [5, 21], "underutilized food" [22] "indigenous aliments" [23, 24], "traditional aliments" [24], "non-timber forest products" [26].

("nutritive value"[MeSH Terms] OR ("nutritive"[All Fields] AND "value"[All Fields]) OR "nutritive value"[All Fields] OR ("nutritional"[All Fields] AND "value"[All Fields]) OR "nutritional value"[All Fields]) AND WILD[All Fields] AND ("plants, edible"[MeSH Terms] OR ("plants"[All Fields] AND "edible"[All Fields]) OR "edible plants"[All Fields] OR ("food"[All Fields] AND "plants"[All Fields]) OR "food plants"[All Fields]) AND ("cote d'ivoire"[MeSH Terms] OR ("cote"[All Fields] AND "d'ivoire"[All Fields]) OR "cote d'ivoire"[All Fields]) AND ("2006"[PDAT]:"2014"[PDAT]) ((((((wild[All Fields] AND ("plants, edible"[MeSH Terms] OR ("plants"[All Fields] AND "edible"[All Fields]) OR "edible plants"[All Fields] OR ("food"[All Fields] AND "plants"[All Fields]) OR "food plants"[All Fields])) OR (spontaneous[All Fields] AND ("food"[MeSH Terms] OR "food"[All Fields]) AND species[All Fields])) OR (neglected[All Fields] AND ("food"[MeSH Terms] OR "food"[All Fields])) OR

("food"[MeSH Terms] OR "food"[All Fields]) AND underused[All Fields])) OR (indigenous[All Fields] AND ("plants"[MeSH Terms] OR "plants"[All Fields])) OR (traditional[All Fields] AND ("food"[MeSH Terms] OR "food"[All Fields])) AND ("nutritive value"[MeSH Terms] OR ("nutritive"[All Fields] AND "value"[All Fields]) OR "nutritive value"[All Fields] OR ("nutritional"[All Fields] AND "value"[All Fields]) OR "nutritional value"[All Fields])) AND ("cote d'ivoire"[MeSH Terms] OR ("cote"[All Fields] AND "d'ivoire"[All Fields]) OR "cote d'ivoire"[All Fields]) AND ("2006"[PDAT]:"2014"[PDAT])

3. Results

A total of 27 studies on wild, spontaneous or collection-type food plants were identified according to the methodology set out by PRISMA GROUP [16]. Among these works, we excluded 14: eleven (11) Communications and three (3) theses, which, although they were listed in the reports of activities of the centres, were not available because unpublished and not available via the internet. After thorough reading of the abstracts of the 13 remaining works, nine (9) were excluded: five (5) studies were purely ethnobotanical, one (1) study was concerned with non-food medicinal plant, one (1) was concerned with the food of chimpanzees and two (2) studies dealt with other topics (production, marketing etc.). Two works were reinstated in the study, communications whose articles had been found on the net. (The activity report for the year including these items had not yet been published at the time of our survey). We conducted a comprehensive analysis of the remaining 6 items. Following this analysis, we excluded three (3) items: one turned out to be a work on a wild plant for medicinal use, another looked into the anti-oxidant qualities of wild fruits without assessing their nutritional value and the third was about non-spontaneous plants. In total, only 3 studies out of 27 or 11% of studies on wild food plants or spontaneous focused on their nutritional values. (Figure 1).



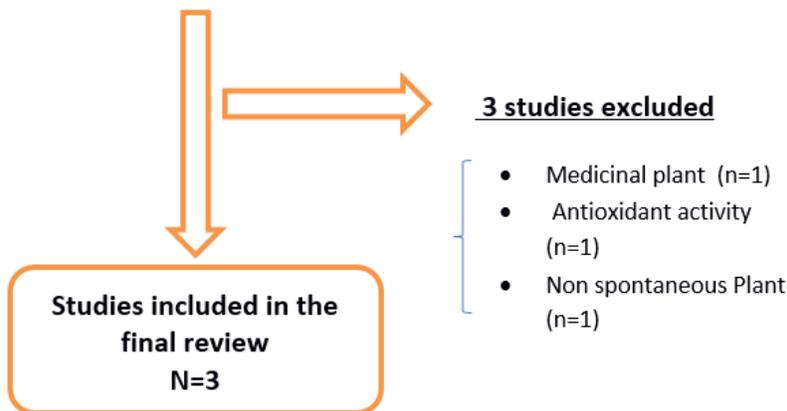


Fig 1: Flow chart of the systematic review of studies on the nutritional value of wild food plants.

These are the studies that were included in the final review: the studies of C. Ake 2006^[27], A. Ekissi of 2011^[28] and Sahore D. 2012^[24]. (Table I)

Table 1: Place of sampling and species studied

Study	Place	Sampling site	Number species studied	Name of the species studied	organs and studied parts
Sahore D. 2012	Abidjan (South)	Market	3	Volvariella volvaceae Beischmiedia mannii (Lauraceae) Irvingia gabonensis (iringiaceae)	Mushroom Seeds Seeds
Ekissi A. 2011	Yamoussoukro (Center)	Uncultivated areas	1	Lippia multiflora	Leaves
Aké C. 2006	Abidjan Anyaman Bingerville (South)	Market	10/20*	Balanites aegyptiaca, Cyperus esculentus L. Dacryodes klaineana, Detarium microcarpum, Landolphia heudelotii Ricinodendron heudelotii Saba comorensis Solanum indicum subsp. Distichum Synsepalum brevipes Voandzeia subterranea	Pulp Tuber Pulp Pulp Pulp Seeds Pulp Whole fruit Pulp Seeds

*10 of 20 species studied were the subject of nutritional studies. The other concerned the anti-radical and anti-bacterial activity

All studies were conducted in urban areas, mainly in Abidjan (economic capital). The acquisition of the plant material was carried out in the marketplace in two (2) out of the three (3) studies. Only one study was exclusively devoted to a plant species, the other 2 covered several species ranging from 3 to 20 (Table I). In the study of Ake^[27], only 10 species out of the 20 studied were the object of nutritional study. The other concerned

the antibacterial and anti-radical activity.

The three studies had no common plant species. Only one study^[24] among the 3 measured, at the same time, the content of macronutrients and that of micronutrients in spontaneous food plants. Analytical methods were in general low-achieving, in some cases titrimetric determination was used for the measurement of vitamin C content. (Table II).

Table 2: Measurement methods used and list of nutrients measured in the nutritional studies of the spontaneous food plants.

Study	Methods of Measurement	Nutrients Measured										
		Prot.	Lip	CH	Ashes	Ca	Na	K	Mg	Fe	Vit C	Vit E
Sahore D. 2012	Atomic absorption spectrophotometry, Kjeldahl method Soxhlet extraction with ether carbohydrate by difference	+	+	+	+	+	+	+	+	+	+	+
Ekissi A. 2011	Kjeldahl method AOAC method (AOAC, 1984; AOAC; 1976)	+	+	+	+	-	-	-	-	-	-	-
Aké C. 2006	Titrimetric determination HPLC/UV assay	-	-	-	-	-	-	-	-	-	+	+

* AOAC: Association of Official Agricultural Chemists

All the studies noted the high nutritional value of spontaneous plant species (table III). However, we note that no study took

interest in their vitamin A or folic acid content.

Table 3: Average nutrient content of wild food plants studied

Study Year	Species studied	Average content for the measured nutrients										
		Proteins (% d.m*)	CH (% d.m*)	Lipids (% d.m*)	Ashes (% d.m*)	Ca (% d.m*)	Na (%d.m*)	K (% d.m*)	Mg (% d.m*)	Fe (% d.m*)	Vit C mg/100g	Vit E mg/100g
Sahore D. 2012	V. volvaceae	17.010 ±0.04	79.440 ±0.24	3.440 ±0.02	0.110 ±0.01	0.120 ±0.04	1.880 ±0.02	1.26 0±0.12	0.130 ±0.01	0.010 ±0.00	-	-
	I. gabonensis	7.230 ±0.80	23.250 ±0.17	63.610 ±0.70	5.91 ±0.30	0.452 ±0.09	0.061 ±0.00	0.678 ±0.01	0.213 ±0.01	0.012 ±0.00	-	-
	B. mannii	7.160 ±0.11	0.610 ±0.004	0.610 ±0.04	3.890 ±0.24	0.104 ±0.02	0.061 ±0.01	0.872 ±0.05	0.071 ±0.00	0.029 ±0.00	-	-
Ekissi A. 2011	L. multiflora -Buds	12.95 ±0.073	<3	<1	10.26 ±0.048	-	-	-	-	-	-	-
	-Young leaves	11.21 ±0.14	<3	<1	10.95 ±0.15	-	-	-	-	-	-	-
	-Mature leaves	9.63 ±0.57	<3	<1	17.9 ±0.43	-	-	-	-	-	-	-
Aké C. 2006	B. aegyptiaca,	-	-	-	-	-	-	-	-	-	8,65	NS
	Cyperus esc. L.	-	-	-	-	-	-	-	-	-	NS	NS
	D. klaineana,	-	-	-	-	-	-	-	-	-	NS	13,20
	D.microcarpum	-	-	-	-	-	-	-	-	-	1,37-8,65	NS
	L. heudelotii	-	-	-	-	-	-	-	-	-	NS	NS
	R. heudelotii	-	-	-	-	-	-	-	-	-	NS	6,28
	S. comorensis	-	-	-	-	-	-	-	-	-	1,37-8,65	NS
	S. indicum subsp distichum	-	-	-	-	-	-	-	-	-	1,37-8,65	13,20
	S. brevipes	-	-	-	-	-	-	-	-	-	NS	NS
V. subterranea	-	-	-	-	-	-	-	-	-	NS	24,70	

The indicated values represent the average of three determination (n=3) % d.m*: % dry matter.

NS: Non Specified

4. Discussion

The analysis of research on spontaneous food plants reveals that over a period of 7 years, nutritional studies of these species accounted for only 11% of all work on wild food plants.

However, the quality of most of the results might be questioned given the conditions in which food is stored in the markets. These storage conditions were mentioned by Aké to explain the low vitamin C content of most of the fruits analyzed [27]. Indeed, it has been shown that factors for the change in the nutritional composition of foods are endogenous (maturity, genetic influences even within a species or variety) and exogenous (sunshine, temperature, humidity and soils). Note that in this same study, although the assays were carried out, some results are not specified. The few studies on the spontaneous food plants fail to go in depth. In the study of Ekissi dedicated exclusively to leaves *Lippia multiflora*, they are recommended as a good source of minerals while only ashes were evaluated without dosage of basic minerals (Na, K, Ca, Mg, Fe). Comparison with the work on the nutritional properties of wild food species in other countries of the world shows that they take into account the major macronutrients and micronutrients. This is the case of work on *Spondias mombin* in Brazil [29], on *Pentaclethra macrophylla* in India [30], or *Maesobotrya barteri*, Nigeria [31], species that are also found in Ivory Coast but which have no nutritional study in publication... The high cost of assays was evoked to explain this limitation at the level of studies in Côte d'Ivoire [4]. This could explain why the analytical methods used are generally low-achieving, as in some cases titration was used [27] and in other cases the protocol is old, as in the 2011 Ekissi study, where the AOAC Methods used are very old (AOAC, 1984; AOAC, 1976) [28] compared to the study of Tirbuski [29], published in the same year, in which the AOAC methods are of 2005 (which is equivalent to a 21 to 29 year gap). This allows us to underline the interest of partnership with research centres of

countries with the same flora and whose research is developed, like India and Brazil. Comparison of species could yield interesting results for genetic studies in a perspective of domestication of these species.

We also note that these studies are not always in line with public health needs. Indeed, although Vitamin A deficiency and folic acid have been identified in the Ivorian population [8], none of these nutrients have been measured in wild food plants. As regards public health, besides the problems of malnutrition, there are also the problems of cardiovascular disease and degenerative diseases, and their increased prevalence justifies the extensive work carried on the anti-radical effects of food at the expense of their nutritional value [25, 27, 32, 33]. However, further research regarding the nutritional properties of wild food plants is very urgent. As Bergeret said [19], the every disappearance of a plant is the loss of the knowledge that is connected to it, namely knowledge about the plant itself and the uses it is the object of. At a time when the whole world is turning to biodiversity to find new food sources, Cote d'Ivoire needs to save their heritage by valuing these previously neglected foods. The limitations of this study were the lack of accessibility of the studies on wild food plants (regarding theses and memoirs), which reduced the number of works included in our analysis. We must also point out that the fact that no study had plant species in common prevented statistical comparison of their nutritional values test results.

5. Conclusion

All studies noted a good nutritional value of spontaneous plant species despite non-optimal conditions for the sampling of plant material and the limitations of nutritional analyzes. Nutrition and biodiversity converge to a common path leading to food security and sustainable development. They are directly related to the Sustainable Development Goals (SDGs) adopted in the

2030 Agenda of the United Nations for sustainable development: zero hunger (Goal 2), Good health and well-being (Goal 3) responsible consumption and production (Goal 12), as well as Life on land (Goal 15). Developing this line of research will undoubtedly help in safeguarding the (Ivorian) flora and achieving food security (as well as in the prevention of cardiovascular and degenerative diseases) in Cote d'Ivoire and potentially worldwide.

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References

- Dupriez H, De Leener Ph. Arbres et agricultures multiétage d'Afrique. Terre et vie. CTA. Wageningen, 1993, 280p.
- Harison P. Une Afrique verte. Paris: Karthala; Wageningen, Pays-Bas: CTA, 1991, 448p.
- Kouame NMT, Gnahoua GM. Arbres et lianes spontanées alimentaires de Gagnoa (centre Ouest de la Cote d'Ivoire). Bois et Forêts des tropiques N, 2008; 298(4):65-75.
- Herzog F, Farah Z, Amado R. Composition and consumption of gathered wild fruits in the V-Baoule, Cote d'Ivoire. Ecol. Food Nutr. 1994; 32:181-196.
- Okafor JC. Edible indigenous woody plants in the rural economy of the Nigerian forest zone. For. Ecol. Manage, 1980; 3:45-55.
- Gauthier-Béguin D. Plantes de cueillette alimentaires dans le sud du V-Baoulé en Côte d'Ivoire. Description, Ecologie, consommation et production. Boissiera 1992; 46:1-341.
- PNN (Programme National de Nutrition). Rapport du Landscape Analysis pour la Cote d'Ivoire. Abidjan, Cote d'Ivoire: Ministère de la Sante et de l'Hygiène publique, 2010.
- Rhoner Fabian, Northrop-Clewes, Taschannen AB, Bosso PE, Kouassi-Gohou V, Erhardt JG, *et al.* Prevalence and public Health Relevance of Micronutrients Deficiencies and Under nutrition in Pre-school Children and women of reproductive Age in Cote d'Ivoire, West Africa, Public Health Nutrition, 2013, 1-13.
- Falconer J. The mayor significance of « minor » forest products. Community forestry note 6, FAO Rome, 1990, 232p.
- Aubreville A. la flore forestière de la Cote d'Ivoire. 2^e éd., Centre technique Forestier tropical, Nogent sur Marne, 3 tomes, 1959.
- Aké Assi L. Flore de la Cote d'Ivoire. Catalogue systématique, Biogéographique et écologie. Mémoire de Botanique Systématique. Conservatoire et Jardin Botaniques de Genève, 2001, vol 1.
- Aké Assi L. Flore de la Cote d'Ivoire. Catalogue systématique, Biogéographique et écologie. Mémoire de Botanique Systématique. Conservatoire et Jardin Botaniques de Genève, 2002, vol 2.
- Ambé GA. Les fruits sauvages comestibles des savanes guinéennes de Cote d'Ivoire: état de la connaissance par une population locale, les Malinkés. Biotechnol. Agron. Soc. Environ 2001; 5(1):43-58.
- Kouamé NMT. Gnahoua GM, Mangara A. Essai de domestication de Ricinodendron heudelotii dans la région du Fromager (Cote d'Ivoire). Journal of Applied Biosciences. 2012; 56:4133-4141.
- Djaha A, Gnahoua G. Contribution à l'inventaire et à la domestication des espèces alimentaires sauvages de Cote d'Ivoire. J. Appl. Biosci. 2014; 78:6620-6629.
- Moher D, Liberati A, Tetzlaff J, Altman DG PRISMA group. Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement. PLoS Med 2009, 6(7): e1000097.doi:10.1371/journal.pmed.1000097
- Okigbo BN. Neglected plants of horticultural and nutritional importance in traditional farming systems of tropical Africa. Acta Horticult 1977; 53:131-150.
- Diarrassouba N, Koffi E. Multiples use of some neglected plant and analysis of the over exploitation impact on their genetic diversity in Cote d'Ivoire. Session 4: use it or lose it? The effect of developing underutilized plant on environmental sustainability and biodiversity. "Underutilized plant species for food, nutrition, income and sustainable development", Arusha, Tanzania, 2008, 8p, Le CNRA en 2008.
- Bergeret A. Nourritures de cueillette en pays sahélien. J. Agr. Trad. Bot. Appl. 1986; 33:91-130.
- Aké Assi L. Quelques plantes alimentaires de cueillette de l'Afrique de l'Ouest. Leur sauvegarde et leur valorisation, 2014. Edition NEI-CEDA. ISBN: 978-2-84487-616-4
- Atato A, Wala K, Batawila K, Woegan A, Koffi A. diversité des fruitiers ligneux spontanés du Togo. Fruits, vegetables and Biotechnology .Global Science Books 2010; 4(Special issue):1-9.
- N'gbesso MF, Fondio L, N'Zi JC, Mahyao A, Agbo AE, Djidji AH. Good agricultural practices for the production on underutilized vegetables in sub-Saharan African: Case of Jute mallow (Corchorus sp) in Cote d'Ivoire. Workshop on Good agricultural practices for underutilized vegetables in sub-Saharan Africa. Arusha, Tanzania, 2009, Le CNRA en 2009.
- Agbo E, Kouame C, Mahyao A, N'zi JC, Fondio L. Nutritional Importance of indigenous leafy vegetables in Cote d'Ivoire. Acta Horticulturae 2009; 806(1):361-366.
- Mahyao A, Kouame C, Agbo E, N'Zi JC, Fondio L. Socio-economic importance of urban markets supply Chains of Indigeonus leafy Vegetables in Cote d'Ivoire. acta horticulturae 2009; 2:489-496.
- Sahoré DA, Nemlin GJ, Techi FA. Study of physicochemical properties of some traditional vegetables in Ivory Coast: seed of Irvingia gabonensis (Irvingiaceae) and Vovariella volvaceae. Food and Nutrition Sciences 2012; 3:14-17.
- Vantomme P, Gazza S. Le défi de la sylviculture en faveur des produits forestiers non ligneux sous les tropiques: de la cueillette a l'agriculture? Bois et forêts d'Afrique 2010; N°304(2):5-13.
- Aké CB, Koné MW, Kamanzi AK, et Aké M. Evaluation de quelque propriétés biologiques de produits de cueillette non ligneux vendus sur les marchés d'Abidjan et ses environs. Pharm. med. Trad. Afr. 2006; XIV:1-17.
- Ekiissi AC, Konan AG, Yao-Kouame A, Bassirou B, Kati-Coulibaly S. Evaluation of the chemical constituents of savannah tea (Lippia multiflora) leaves. J. Appl Biosci. 2011; 42:2854-2858.

29. Tiburski Julia Hauck, Rosenthal Amauri, Deliza Rosies, de Oliveira Godoy Ronoel L., Pacheco Sidney. Nutritional properties of yellow mombin (*Spondias mombin* L.) pulp. *Food Research International*, 2011; 44:2326-2331.
30. Alinnor IJ, Oze R. Chemical evaluation of the nutritive value of *Pentaclethra macrophylla* benth (African oil Bean) seeds. *Pakistan journal of Nutrition*. 2011; 10(4):355-359.
31. Ogbuagu Marc Nwosu, Agu Basil. Fruit nutritive composition of *Maesobotrya barteri*, an under-exploited tropical African tree. *Fruits Journal*. 2008; 63:357-361.
32. Gauze-Gnagne C, Lohoues E, Monde A, Djinhi J, Camara C, and Sess E. Evaluation of the Anti-oxidant Effect of *Spirulina* on Marathon Runners in Cote D'ivoire. *J Nutr Food Sci*. 2015; 5:392. doi:10.4172/2155-9600.1000392
33. Yao K, Koné MW, Bonfoh Bassirou, Kamanzi K. Antioxidant activity and total phenolic content of nine plants from Cote d'Ivoire (West Africa). *J App Pharm Sci*. 2014(08): 4(08):036-041.