

DOI: 10.18697/ajfand.76.13810**LEAFY AMARANTHUS CONSUMPTION PATTERNS
IN OUAGADOUGOU, BURKINA FASO****Hilou A^{1*}, Ouedraogo I¹, Sombié PAED¹,
Guenné S¹, Paré D¹ and Compaoré M¹****Adama Hilou**

Corresponding author email: hiloudio@gmail.com

¹Laboratoire de Biochimie et de Chimie Appliquées (LABIOCA), Department of Biochemistry and Microbiology, UFR/SVT, University Ouaga I Prof Joseph KI-ZERBO, Ouagadougou, Burkina Faso



ABSTRACT

There is a new attention to vegetables as vital components of daily diet. A concerted effort to raise their standing has begun to change mentalities and to fuel a rapid growth of traditional leafy vegetables marketing and consumption in African cities. However, little is known about the production and consumption patterns of these plant foods. This study examined, through a field survey the socio-economic, food consumption and conservation aspects of leafy vegetables in the region of Ouagadougou. It was found that leafy vegetables are cultivated under both rain-fed and irrigated conditions in the villages and also in the city's gardens. The study has demonstrated that there is considerable indigenous knowledge on the leafy vegetables of the region. Amaranth species are the most cultivated and marketed and have potential for commercialization. They are used for many dishes in the local kitchen. Leafy Amaranths are consumed during all seasons even though they are more available (and cheap) during rainy season (June to end October). Ninety-four per cent of the interviewed people use vegetable Amaranth in sauce. There is a growing trend to use cultivated (introduced) species of Amaranth, which were brought to Africa by colonial powers and gained popularity because they were associated with high status. The introduced species are spreading quickly in a spontaneous manner. This can be a threat to biodiversity. There is need for a conservation initiative for the native species. In the commercialization of leafy vegetable and in particular for Amaranth, women play an important role. That could be optimized for marketing purpose to improve leafy vegetable adding-value. Because transportation is a cost increase factor, and given that cities should be targets for increased consumption, it is necessary to promote peri-urban agriculture of leafy vegetables, by policy guidelines. There is a need of documentation and dissemination of indigenous knowledge on indigenous leafy vegetables.

Key words: vegetables, African greens, Amaranthus, micronutrients, biodiversity, horticulture, Ouagadougou, Burkina Faso



INTRODUCTION

Traditional leafy vegetables are common traditional food plants of developing countries. During and after colonization, these food plants suffered neglect as ‘non-civilized people foods’ [1]. For poor people, animal proteins are not cost-available and cereals comprise most of their diet. Vegetables are available sources of proteins, vitamins, minerals and essential amino acids [2]. In Burkina Faso, food safety is a permanent challenge [3]. For example, anemia is widespread in infant and young women because of the poor iron absorption from cereal-based meals due to their high level of phytic acid [4].

Millogo-Rasolodimby’s work showed that African leafy vegetables represent inexpensive high quality nutritional source for the poor population of the Kadiogo region [5]. Production of African Leafy Vegetables (ALVs) has been expanding and becoming increasingly commercialized especially within African capital cities and their outskirts. The priority species marketed within and around Ouagadougou include various species among which leafy Amaranth (*Amaranthus spp.*) is the most popular and abundant.

The Amaranthaceae family consists of herbaceous, fast growing plants with a vegetable yield of 4.5 tons dry matter/hectare for 4 weeks after sowing [6]. Amaranth’s favourable agronomic traits include C4 photosynthesis system and tolerance to high soil salinity, dry areas, and poor or polluted soils [7]. Studies on the American species showed that Amaranth, by their high protein content (12-17%), well-balanced proteins (good ratio of amino acids), unsaturated fatty acids (45% linoleic acid), and antioxidants (carotenoids, pigments), is one of the more promising food ingredients, capable of complementing cereal-based diets [8]. Leafy Amaranth which forms an essential diet component of Ouagadougou region contributes significantly to dietary requirements for essential nutrients [5, 8, 9].

Vegetable Amaranth has received significantly less research attention than grain Amaranth. Leafy Amaranth has been rated considerably higher in many nutritive factors (for example protein, vitamin C and dietary fiber, minerals such as calcium, iron, zinc, magnesium, phosphorus), carotenoids and nutraceuticals than most vegetables [10,11,12,]. Pharmacological properties of different Amaranth species also have been investigated. It was determined that *Amaranthus paniculatus* and *Amaranthus cruentus* are good sources of flavonoids, especially for rutin [13, 14]. Usage of Amaranth as livestock feed indicated relatively high protein qualities [11].

The purpose of this work was to collect data about food and nutraceutical uses of local leafy vegetables and particularly those of Amaranth in order to guide research on the consumption and commercial potentials of these plants.

METHODOLOGY

Study site

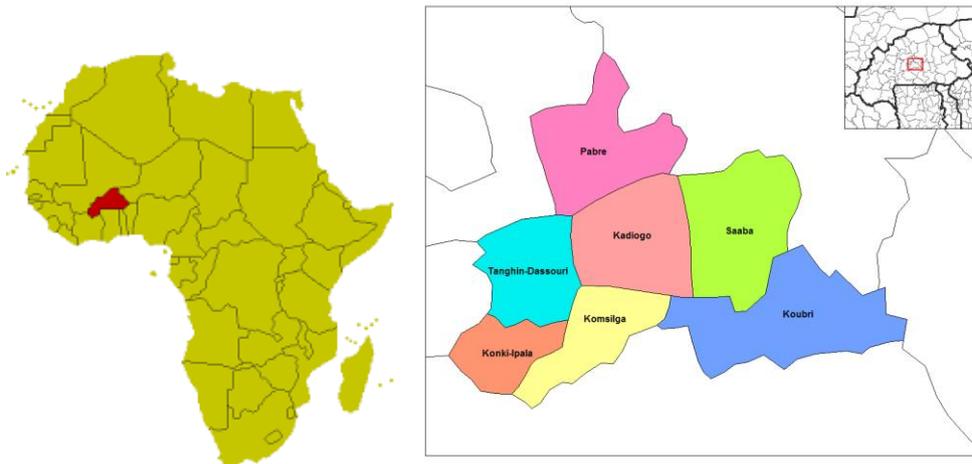


Figure 1: Study area in Burkina Faso

With an altitude average of 350 m, Burkina Faso is a West African country with poor soils made of granites. Ouagadougou region, in the center, lies between 11°24' and 11°29' of Latitude North and between 0°49 and 0°54 of Western Longitude. The climate is characterized by a long dry season (from October to the end of April) and a short rain season (from May to September), with an average rainfall of 650-800 mm and an average annual temperature of 32° C. The principal economic activity is subsistence agriculture [3].

Ouagadougou was chosen as a study site because it is the biggest cosmopolitan city of the country, and there exists a substantial peri-urban and urban vegetable production. The population of Ouagadougou (and its suburbans) is approximately 2.2 million [3].

Data collection and sampling procedure

The investigation consisted of collecting information on leafy vegetables and particularly *Amaranthus* species. Fifty-one (51) persons (25-60 years old) were interviewed. They were interviewed (using the local language Moore and/or French) in nine sites in the region of Ouagadougou (this included 4 markets in the urban area of Ouagadougou: Katr yaar, Dasasgho, Samandin, Kossodo and 4 markets in the surrounding rural districts of Ouagadougou: Saaba, Kamboinssin, Loumbila, Koubri and in a village (konki-Ipala) located at about 30 km from Ouagadougou) (figure 1). The survey took place from February 2009 to January 2010 using a pre-tested questionnaire that included socio-demographic information, socio-economic aspects of the consumption, sources of provisioning, context of consumption, food mode of use, nutraceutical uses and ecological availability of amaranth.

Data analysis and presentation



Descriptive statistical method was employed to analyze and summarize the ethnobotanical data on the reported leafy Amaranth plants and associated knowledge. The relative importance of different *Amaranthus* species in the community was determined based on the consensus of informants' responses. It was calculated from the proportion of informants who independently reported knowledge on a given use following the approach used by Phillips and co-workers [15].

Fidelity level (FL) was used to assess the main patterns of ethnobotanical uses of the most used *Amaranthus* species of the region. The formula used was $FL = N_p/N \times 100$, where N_p is the number of informants stating a type of use of the plant as a leafy vegetable/medicinal dietary plant and N is the total number of informants citing the plant as leafy vegetable or for medicinal use [15]. The values of FL range from 0 to 100, and increasing values of FL for a species indicate a main consumption pattern.

This study was carried out following the International Society of Ethnobiology Code of Ethics [16]. Specimen identification was completed with the help of a botany expert (Prof Jeanne Millogo from the ecology laboratory of university of Ouagadougou) and these specimens were stored in the Herbarium of "le Centre de Biodiversité".

RESULTS

Socio demographic information

Forty respondents (which represents 78, 44%) of the total 51 were female and 11 people (which represents 21, 56%) were men.

More than 70% of the respondents were relatively young (less than 45 years old). This is a good picture of the region's population [3] (Figure 2).

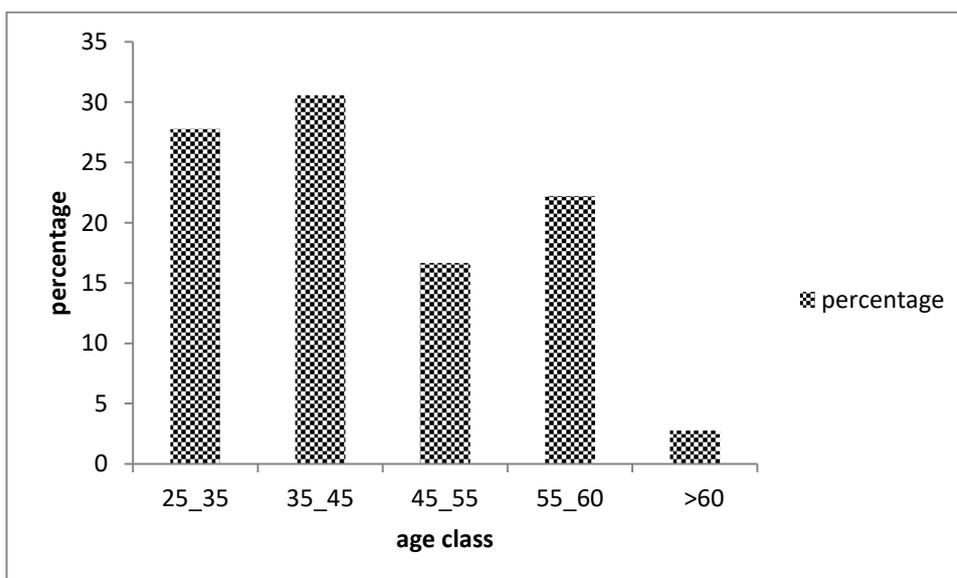


Figure 2: Age class of the informants

Less than 5% of children in respondent families had a level of education beyond primary education (table 1).

More than 55% of the respondents were living in a family with 6 to 10 members (Figure 3).

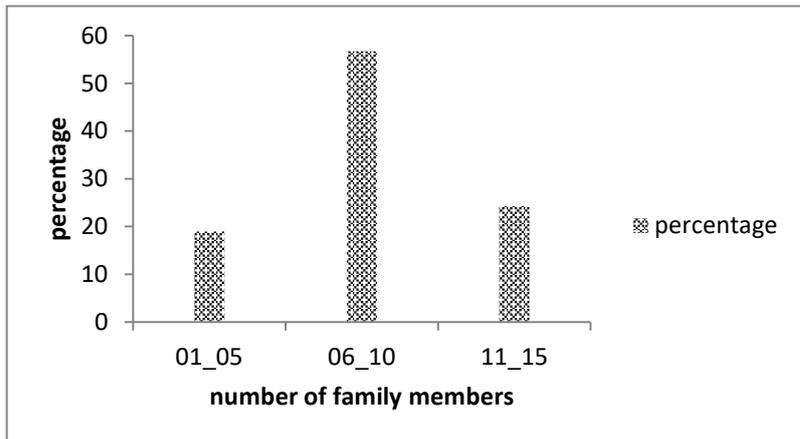


Figure 3: the size of the informant's family

More than 75% of the respondents had as agriculture or informal trading as the main activity.

Almost all the respondents consumed food plants (wild or cultivated, tree or herbaceous plants) during all seasons. These food plants are more available during rainy season (June to end October).

Consumption patterns

About parts used, it was revealed that leafy stems (and in preference, young and fresh leafy stems) are the most consumed part of this leafy vegetable. It is tedious to cut down the leaves, so the people usually prefer to use young parts of leafy stems (figures 4 and 5).

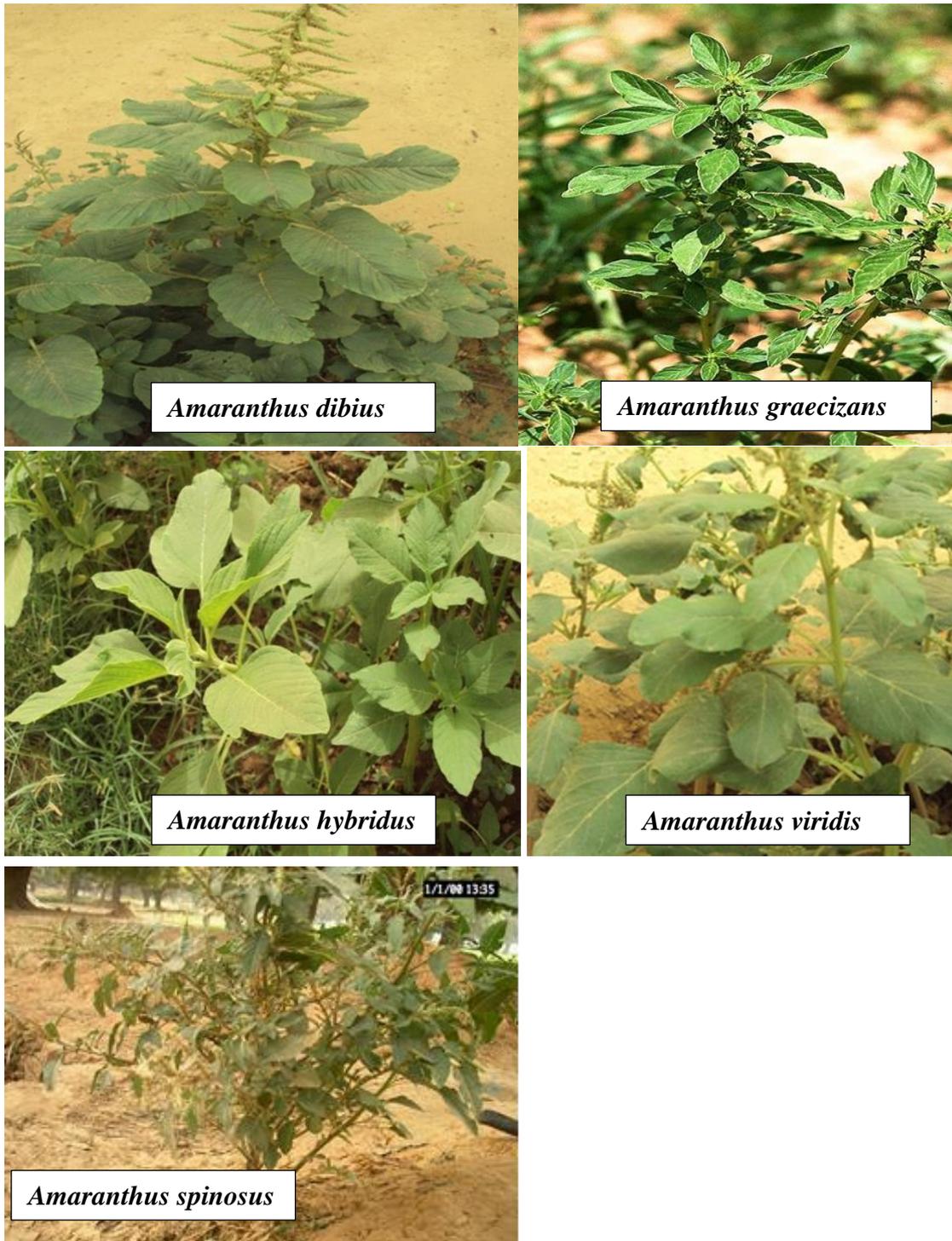


Figure 4: pictures of the most used (five) Amaranthus species

It was reported that vegetable amaranths are used as well for human consumption as for forage. The main source of provisioning is the market for about 80% of people living in town and bush or field for more than 70% of villagers. The cost of leafy amaranths on the market was considered to be accessible by the majority of surveyed people (80.39%) even if the price increased during dry season because of the low availability.

In rural areas Amaranth vegetables are consumed in large amounts during starvation periods (Figure 6) when it is usually processed as a mixture of cereal porridge and leafy stems, called “baabenda” in the local Moore language.

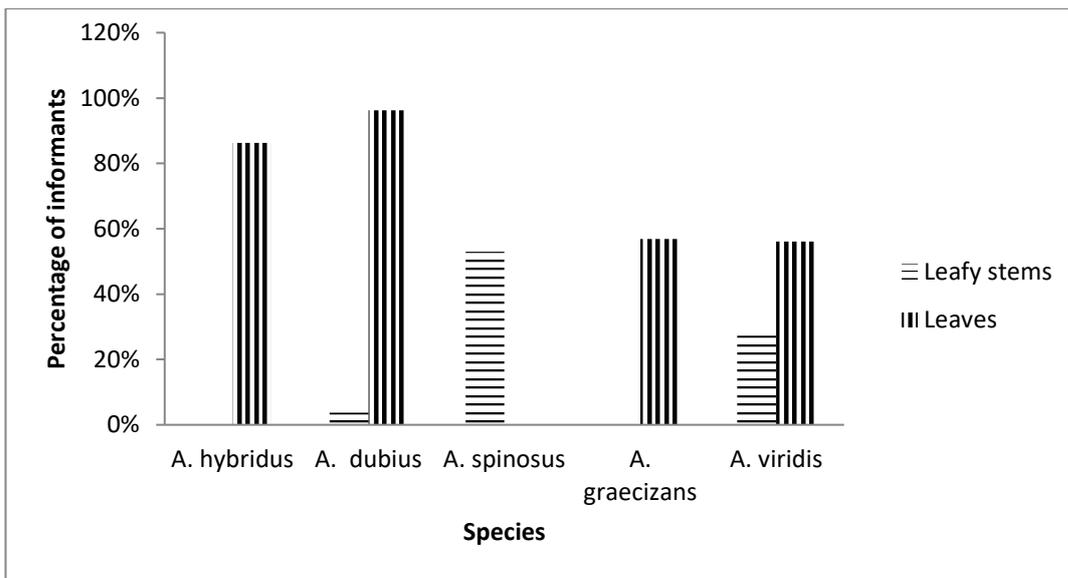


Figure 5: Used parts of the plants

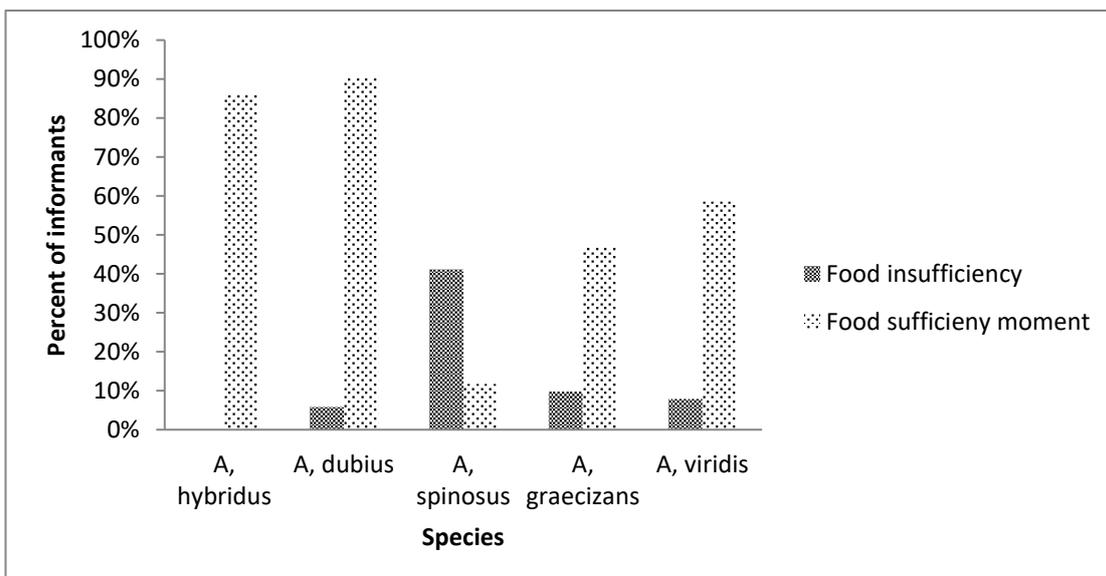


Figure 6: Consumption context of different Amaranthus species

About the cooking mode, the following data were recorded (Tables 2 and 4):

Leafy Amaranths are rarely consumed raw (like salad). The modes of preparation are diverse: (47% of surveyed people consume the leaves boiled with or without cereal-based meal like couscous); but when that is feasible, 94% of the interviewed people use Amaranth leafy stems in groundnut sauce.

Some species (*A. hybridus* and *A. dubius*) are cooked directly with other sauce or meal component whereas others (*A. graecizans* and *A. spinosus*) need precooking (one or several boiling and rinsing before adding into a sauce or meal) (Table 4). The precooking is supposed to help to eliminate or to reduce some anti-nutrient factors such as phytic acids or oxalates. *Amaranthus viridis* is used in both ways depending on season (precooking during dry season and direct cooking during rainy season). For precooking, the leaves are first cooked in a great volume of water and then the precooked leaves are dewatered. Leafy Amaranths are sometimes prepared in association with other vegetables like *Cleome gynandra*, *Cleome viscosa* (Capparidaceae), *Hibiscus sabdariffa* (Malvaceae), and *Basella alba* (Basellaceae).

The survey revealed that in addition to its nutritional use, Amaranths also possess therapeutic properties. In fact, for 5% of the respondents (Table 4), Amaranth leaves are used as functional or nutraceutical food: against constipation, stomachache, as a diuretic, against worms, for convalescent persons, for quick growing of children and for tooth arising of babies.

Biodiversity issues

Whether wild or cultivated species of *Amaranthus* are preferred for consumption, the survey showed that:

- The wild (or spontaneous) *Amaranthus* species (*A. dubius*, *A. graecizans*, *A. spinosus* and *A. viridis*.) are more used in rural areas and particularly during the rainy season (from May to October) while, the cultivated species (*A. hybridus*) is largely consumed in towns and during all seasons (Figure 7).
- The use of *A. spinosus* is on the decline, and for 41% of interviewed people, this species is considered only as a famine food plant. It is said to have a bitter taste and is usually consumed in small quantities as substitute when no other *Amaranthus* or other vegetable is available.
- On the resources availability (and biodiversity) issues, the surveyed people said that there are new ecotypes of *Amaranthus* in the field and bush. They spontaneously grow after the beginning of the rainy season. These new ecotypes are hybrids between *A. hybridus* and some wild species, or they are field adapted forms of the cultivated *A. hybridus* or other ornamental *Amaranthus* (*caudatus*, *cruentus*, among others).

Figure 7 indicates that cultivated species are more consumed in town whereas wild or spontaneous ones are preferred in rural areas.



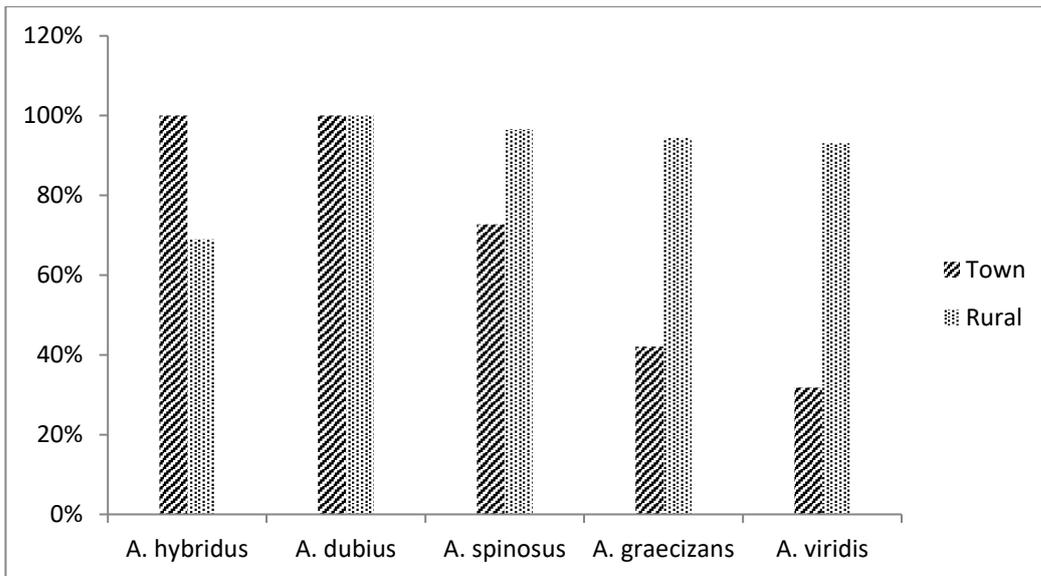


Figure 7: Comparison of the use of the local Amaranths among people living in town or in rural areas

Analysis of fidelity level of the main consumption patterns of Amaranth

This data analysis (Table 4) allowed stating that:

-Main origin of the Amaranth vegetable consumed in Ouagadougou region is wild (FL of 62.6 %) because most of amaranth consumers are people from rural areas (of the region) where cultivated (*A. hybridus*) and semi-cultivated (*A. dubius*) species are rare whereas wild species (*A. graecizans*, *A. spinosus* and *A. viridis*) are predominant (with a FL of 96 %). Except for *A. spinosus* (whose stems are spiny), leafy stems are the most used part of the Amaranth.

-People have little knowledge of the supposed nutritional intake from Amaranth vegetable consumption. This calls for biochemical analysis and sharing of the results with the local population.

DISCUSSION

The surveyed population comprised about 80% women and 20 % men. Indeed, vegetable use in Africa has a gender aspect. Traditionally (and that still occurs in modern African society) women are responsible in the social economy for the sauces preparation. The men (husbands or fathers) provide cereals or tubers and women (wives or daughters) gather the food plants (vegetables). This aspect may be taken into account when a marketing issue is in discussion. Women are more suitable for vegetable trade and marketing in Africa, because they are supposed to better know the species and the best practices.

The mode of cooking could inform on some knowledge of the biochemistry of the vegetable. The “rinsing-cooking” habit shows that the consumers are aware of the

presence of soluble anti-nutrients like nitrates and oxalates [4]. This knowledge could be utilized for introducing new varieties with low content of anti-nutrients.

The mixing of leafy Amaranth with other local vegetables may be designed for nutrient complementation or for mitigation of adverse effects of any of the combined vegetables [5, 9]. *Amaranthus hybridus*, the most cultivated species is the most marketed and also the most consumed one when compared with the other Amaranth species. It is also the most expensive on the market. This could be related to the best nutritional properties of this species, as showed by earlier findings: *A. hybridus* showed the best content in proteins with 56 ± 3.37 mg BSA Equivalent/100 mg for the aqueous extract [17]. This species also has many interesting nutraceuticals. The greater content of bioactive polyphenols is found in the aqueous decoction extract of *A. hybridus* (12.73 ± 1.61 mg GAE/100 mg of extract) whereas this species showed the weakest level of tannin (anti-nutrient factor) [17].

The survey data evidenced a risk of weakness of the wild Amaranthus species. The rate of local homozygote wild species is decreasing. Most of the cultivated species are introduced from South America or Asia [6]. There is a need for research on the local wild species in order to protect the biodiversity. With the changing climate wild genotypes could be useful phylogenetic resources for adaptation.

When produced far from the consumption areas, price can influence vegetable consumption, as sometimes it occurs with transportation constraints [18, 19]. In Ouagadougou, leafy vegetables are produced in urban and peri-urban areas to supply the markets [20]. Peri-urban vegetables are considered to be fresher by consumers [21]. The urban and peri-urban production of leafy Amaranth year-round can thus improve consumer need of fresh vegetables and try to address the seasonal aspect of vegetable availability in this Sahelian region (with only 3-4 months of rain). For the moment, almost no supermarket deals with leafy amaranth selling. Could it be that people who shop in supermarkets are not interested in this vegetable? Exotic vegetables such as beets and others are, however, sold in many supermarkets.

People preferred to buy their vegetables mainly at street markets. The low credibility of quality claims on packaging and the higher prices in supermarkets may hinder sales of processed vegetables [21].

Despite the reasonable frequency of vegetable intake found in this study, the quantities consumed remain low and cooking methods are less efficient, causing the loss of nutrients [10]. There are, however, data showing that many people and particularly infants and women of childbearing age suffer from avitaminosis and anemia. Vegetables are the most affordable and sustainable dietary source of vitamins, trace elements, and other bioactive compounds. Improved vegetable production and consumption is thus regarded as the most direct, low-cost method for the urban and rural poor to increase micronutrients in their diets [19].



CONCLUSION

The general objective of this work was to contribute to the documentation on the food or nutraceutical consumption of Amaranth vegetables in the African context. Obtained results allow asserting that these plant foods are important components of the local diets. The rate and mode of use of leafy Amaranth in the Ouagadougou region evidenced as well an empirical knowledge by many people of the interesting nutritional properties of these vegetables as the eventual risks linked to anti-nutrients. Such context is an advantage for greater consumption of African under-exploited and under-utilized nutrient-rich and health-promoting leafy vegetables. Promoting the nutritional importance of vegetables could increase consumption and improve the nutritional status of all low-income groups. The influence of some social taboos that hinder increased consumption of vegetables will need to be addressed through nutrition education and extension communication programs. Such programs would also improve nutritional knowledge and awareness of which was rated low by respondents in this study, to further enhance the consumption of vegetables.

The research has been funded by the International Foundation for Science (IFS) project grant (Project E/4627-1).

Table1: education level of members of the surveyed families

Education level	Primary (6 years)	Secondary (10 years)	High school (13 years)	University Level
Percentage	4.68	2.45	0.47	0.37

Table 2: Type of meal for which Amaranthus species are used and supposed nutritional contribution

Species	<i>A. hybridus</i>	<i>A. dubius</i>	<i>A. spinosus</i>	<i>A. graecizans</i>	<i>A. viridis</i>
	Baabenda	Baabenda	Baabenda	Leaves sauce	Baabenda
Type of meal	Leaves sauce	Leaves sauce	Leaves sauce	Couscous with leaves	Groundnut sauce
	Groundnut sauce	Groundnut sauce	Groundnut sauce		Leaves sauce
			Couscous with leaves		
Supposed nutritional contribution	Vitamin (9.40%)	Vitamin (1.88%)	Unknown	Unknown	Unknown

Baabenda is a traditional meal prepared with cereals and leafy stems
 Leaves sauce is a sauce consisting mainly of one or many type of leaves
 Groundnut sauce is a sauce consisting of groundnut paste and one type of leaves
 Couscous with leaves is a couscous including leaves



Table 3: Medicinal use

Species	<i>B. hybridus</i>	<i>B. dubius</i>	<i>B. spinosus</i>	<i>B. graecizans</i>	<i>B. viridis</i>
Medicinal uses	Constipation, diuretic (3.77%)	Constipation fever, stomach ache (5.65%)	Diuretic, furoncle, burns (7.54%)	Vermifuge (1.88%)	Diuretic, purgative (3.77%)

Table 4: Fidelity level of the main consumption patterns of Amaranths

		<i>A. hybridus</i>	<i>A. dubius</i>	<i>A. spinosus</i>	<i>A. graecizans</i>	<i>A. viridis</i>	Fidelity level
origin	Wild	11.76%	80.39%	52.94%	56.86%	60.08%	62.56 (wild)*
	Cultivated	72.54%	3.04%				
Rural/urban	Rural	68.96%	100%	96.55%	94.41%	93.10%	96.015 (rural) *
	Urban	100%	100%	72.72%	42.10%	31.81%	100 (urban) * ¹
Consumption Period	Starvation		5.88%	41.17%	47.06%	58.60%	48.94 (starvation period)* ²
	All time	86.27%	90.19%	11.77%	9.80%	7.85%	88.23 * ¹
Used parts	Leafy stem	86.27%	96.25%	0	56.86%	56.05%	73.86* ³
	Leaves	0%	3.7%	52.94%	0%	27.30%	16.78
Nutritional intake supposed	Vitamin	Vitamin (1.88%)	Vitamin (9.40%)	Unknown	Unknown	unknown	2.25
Cooking procedure	Direct	86.27%	98.03%	22.65%	6.36%	75.56%	92.15* ¹
	30 min precooking	0%	0%	30.33%	37.25%	7.25%	24.94* ²
Medicinal use		3.77%	(5.65%)	(7.54%)	(1.88%)	(3.77%)	4.52

*Only the score for *A. dubius*, *A. spinosus*, *A. graecizans* and *A. viridis* were taken into account

*¹ Only the score for *A. hybridus* and *A. dubius* were taken into account

*² Only the score for *A. spinosus*, *A. graecizans* and *A. viridis* were taken into account

*³ Only the score for *A. hybridus*, *A. dubius*, *A. graecizans* and *A. viridis* (non spiny species) were taken into account



REFERENCES

1. **NRC.** Lost Crops of Africa: Volume II: Vegetables. National Academies Press, 2006: 1-32.
2. **Okafor JC** Horticultural Promising indigenous wild plant species of the Nigerian Forest zone. *Acta Hort.* 1983; **123**: 165 – 176.
3. **Institut National de la Statistique et de la Démographie (INSD) and ORC Macro** Enquête Démographique et de Santé du Burkina Faso 2003 Calverton, Maryland, USA, 2004.
4. **Paul V, Verma S and A Paul** Effect of cooking and processing methods on oxalate content of green leafy vegetables and pulses. *As. J. Food Ag-Ind.* 2012; **5(04)**: 311-314.
5. **Millogo-Rasolodimby J** Plantes consommées en période de disette alimentaire au du Burkina Faso. PhD thesis, Université de Ouagadougou, 2001.
6. **Teutonico R and D Knorr** Amaranth: composition, properties, and applications of a rediscovered food crop. *Food technol.*, April 1985:49-60.
7. **Marcone FM** First report of the characterization of the threatened plant species *Amaranthus pumilus* (Seabeach Amaranth). *J Agric. Food Chem.* 2000; **48**:378-382.
8. **Silva-Sanchez C, Barba de la Rosa AP, Leon-Galvan M F, De Lumen BO, De Leon-Rodriguez A and E Gonzalez De Mejia** Bioactive Peptides in Amaranth (*Amaranthus hypochondriacus*) Seed. *J. Agric. Food. Chem* 2008; **56**: 1233–1240.
9. **Lykke A, Mertz O and S Ganaba** Food consumption in rural Burkina Faso. *Ecol. Food and Nutr.* 2002; **41**: 119-153.
10. **Shukla S, Bhargava A, Chatterjee A, Srivastava J, Singh N and SP Singh** Mineral profile and variability in vegetable amaranth (*Amaranthus tricolor*). *Plant Food. Hum. Nutr.* 2006; **61**: 23-28.
11. **Kadoshnikov SI, Kadoshnikova IG, Kulikov YA and DM Martirosyan** Researches of fractional composition of protein of amaranth. *Curr. Nutr. Food Sci.* 2008; **4**: 196-205.
12. **Ozbucak TB, Ergen O and S Yalcin** Nutrition contents of some wild edible plants in Central Black Sea Region of Turkey. *Inter. J. Natural Engineering Sci.* 2007; **1**: 11-13.

13. **Nsimba RY, Kikuzaki H and Y Konishi.** Antioxidant activity of various extracts and fractions of *Chenopodium quinoa* and *Amaranthus spp.* seeds. *Food Chem.* 2008; **106**: 760-766.
14. **Nacoulma OG** Plantes médicinales et pratiques médicales traditionnelles au Burkina Faso: cas du plateau central. PhD Thesis, Université de Ouagadougou, 1996.
15. **Phillips O, Gentry AH, Reynel C, Wilkin P and CB Galvez-Durand** Quantitative Ethnobotany and Amazonian Conservation. *Conservation Biology* 1994; **8(1)**:225-248.
16. **International Society of Ethnobiology Code of Ethics** (with 2008 additions). [<http://ethnobiology.net/code-of-ethics/>]. Accessed 01/22/2016.
17. **Ouedraogo I, Hilou A, Sombie PA ED, Compaore M, Millogo J and O G Nacoulma** Nutraceutical Assessment of Four *Amaranthus* Species from Burkina Faso. *Current Research J. Biol. Sci.* 2011; **3(5)**: 451-458.
18. **Margiotta M and P Moustier** Rapport du groupe de travail. Agriculture périurbaine, approvisionnement et distribution alimentaires des villes de l'Afrique francophone, regional Workshop Proceedings, 1997 FAO-ISRA.
19. **Hart AD, Azubuike CU, Barimala IS and SC Achinewhu** Vegetable Consumption Patterns of Households in Selected Areas of the Old Rivers State in Nigeria. *Afri J. Food Agric. Nutrit. Dev.* 2005; **5 (1)**: 1-19.
20. **Gockowski J, Mbazo'o J, Mbah G and FT Moulende** African traditional leafy vegetables and the urban and peri-urban poor. *Food Policy* 2003; **28**: 221-235.
21. **Bridier BE** Etude de la perception de la qualité des légumes par les consommateurs de Hanoi (Vietnam). Cas particulier de la qualité sanitaire. ESAT "Développement agricole tropical. Option: Valorisation des productions". Montpellier, CNEARC. 2000: 149.